Orbit

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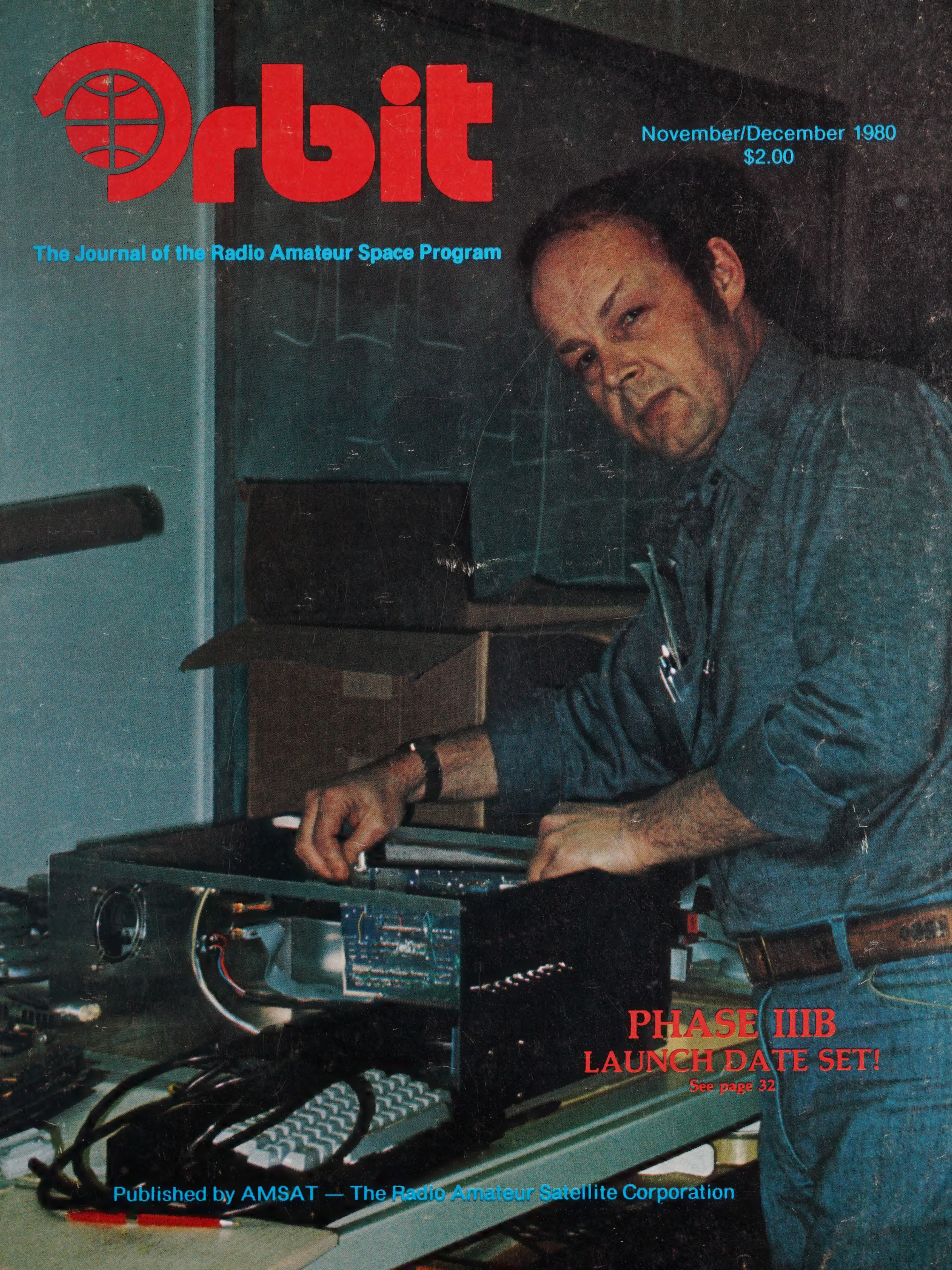

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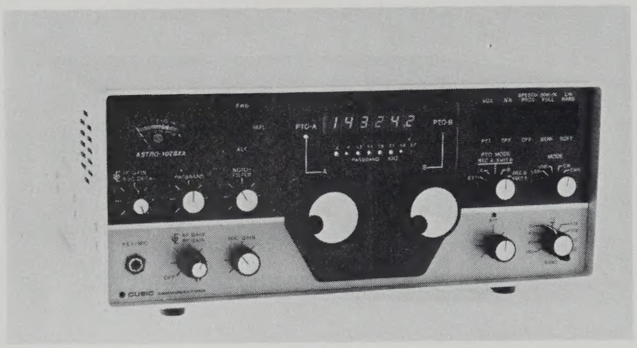

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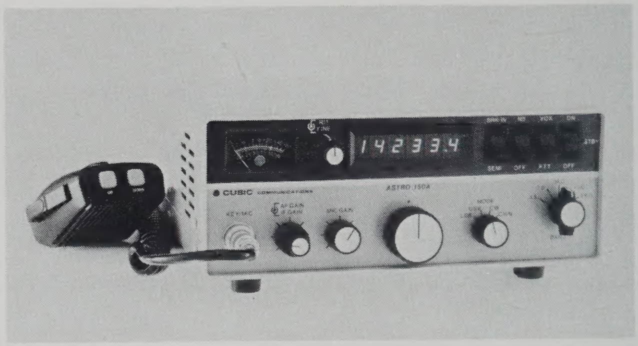

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Orbit

November/December 1980
Volume 1 Number 4

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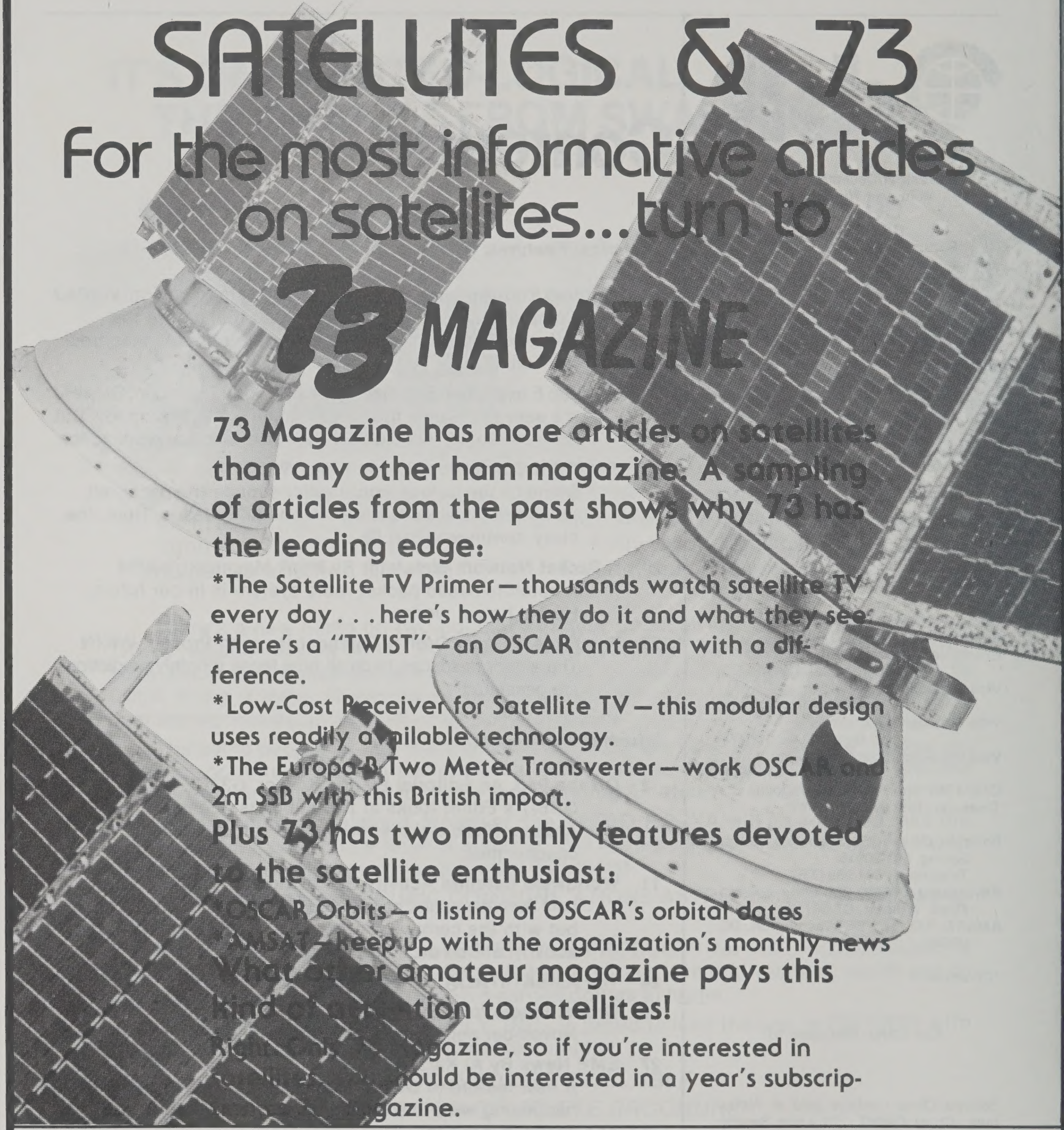

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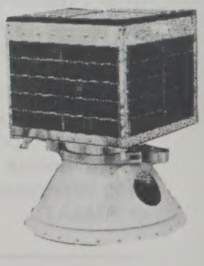

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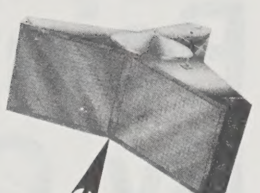

An Editorial By Joe Kasser, G3ZCZ*

Computerizing Amateur Radio:

This issue of *ORBIT* includes a number of articles featuring microcomputers and digital techniques. For the last few years, AMSAT has been pioneering the applications of microcomputers to Amateur Radio. The Phase III spacecraft is itself designed around a microcomputer and automated telemetry tracking and command stations have been in use since the 8008 first became available five years ago. A full blown microcommputer project 'the AMSAT-GOLEM-80' was developed to allow anyone to build an S-100 system suitable for use in the amateur radio station and in the Phase III environment. UOSAT, to be launched later next year will also carry an on-board microcomputer and will send back data in digital format, designed for computer processing. Automated ground stations using AMSAT-GOLEM-80 project developed hardware and software can make your regular operating (conventional and satellite) much easier. Computers perform dull repetitive chores with the same degree of enthusiam as they perform a highly sophisticated interesting project. Thus, passing satellites can be tracked automatically or RTTY QSO's can be held almost automatically. The computer can call CQ, establish a QSO and send your brag tape even before it alerts you to the fact that a QSO is in progress. The day is not too far away when contests will be worked automatically.

Digital and Packet radio networks are ideal for use in the satellite environment. A message can be input to the network and will be delivered with the minimum amount of delay. WA2LQQ wrote an interesting piece about it in *ORBIT* #1. His article is fiction this year but will be fact before too long.

In the general area of Amateur Radio microprocessors are appearing built into transceivers both at hf and at vhf. Their usefulness and low cost ensures that they are here to stay. Their uses are limited only by the imagination of their owners. At vhf, openings can be detected by programing the scanning receiver to tune for different beacons. At hf, remote control, and other techniques become simple.

Just as the NASA space program would not have been able to land men on the moon without computers, there is no future in the Radio Amateur Space Program without microcomputers, and as *ORBIT* Magazine is the Journal of the Radio Amateur Space Program, it will cover all its aspects, including microcomputers. *ORBIT* however will not become a computer magazine. Computers are only one facet of the Radio Amateur Space Program and will be treated as such in these pages.

A New Amateur Band:

Do you know that the AMSAT Phase III Program is designed to bring you a new world wide DX/local amateur band via communications satellite. This new band will be scarcely affected by the ionosphere, so that unlike the current hf bands or the three new bands we gained at WARC-79, propagation via this band will be 100 per cent predictable. For the first time, the technology used to provide the reliability, predictability and ease of use of a two-meter repeater will be applied to provide world wide coverage. The AMSAT Phase IIIB satellite will be capable of providing repeater quality contacts to all stations within its range, be they local to you, or DX ..up to half way around the world. There will be no skip zones in this new satellite communications band: for example, stations in New York, New Jersey, London, Paris, Tel Aviv, Moscow and Tokyo will be able to hold a round table QSO. The potential for nets, Jamboree-on-the-air, RTTY and computer, emergency and public service communications is tremendous.

You owe it to yourself to be informed about this new band. The new band almost 'happened' last May but the launch vehicle malfunctioned and the Phase IIIA satellite did not achieve orbit. Our replacement Phase IIIB satellite is a million dollar undertaking. We are going full steam ahead secure in the knowledge that we can do our part to make the new band happen following the successful launch of Phase IIIB. If you are not already a member of AMSAT why don't you join and receive regular news as to the status of the Phase III Program and AMSAT's other projects right here in *ORBIT* Magazine. We still have two working communications satellites in orbit (AMSAT-OSCAR's 7 and 8) and are building 'a satellite for Science,' UOSAT, due for launch in the fall of 1981. At this time it is planned that it will carry scientific experiments as well as a slow-scan television (SSTV) camera. This satellite will be ideal for use in classrooms all over the world for live demonstrations of various aspects of space research.

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*Editor, *ORBIT* Magazine

Pointing Your Antenna By Computer

Want to computerize azimuth and elevation control so that you can be free to do more important things? Here's how to go about it.

By Skip Reymann, W6PAJ*

The expression is '...busier'n a one-armed paper hanger.' That certainly described my early efforts at working through OSCAR 6: one hand on the key, one tuning the receiver, one following with the transmitter frequency control, another hand alternating between elevation and azimuth rotor controls...wait a minute, that's a few more hands than I came equipped with. It quickly became obvious that my alternatives were either to entice someone into the shack to help, or to dispense with some of those motions to reduce the workload. What was dropped was the constant antenna pointing. With typical amateur beamwidths in excess of thirty degrees, I figured bumping the antennas every two minutes or so would be enough.

It was. For OSCAR's 6, 7, and 8, I used the 'ballpark' approach to antenna pointing. The satellites cooperated nicely, and returned my signals acceptably.

Advent of Phase III

The planned launch of Phase IIIA ended that solution. My station would be one of the dozen or so worldwide which would furnish ground support to the computerized satellite. The primary activities would be making relatively precise range measurements, and receiving and recording telemetry, automatically checking each parameter within certain limits. With the advanced data transmission and reception techniques to be used, and the heavy workload, a computer was absolutely necessary.

Funny thing about the computer side of the amateur hobby: once you have the machine and have reached a basic understanding with it as to who is in charge, you start thinking of how much of your workload it can assume. Why not use a few spare microseconds of computer time to handle the chore of antenna pointing?

Using ideas suggested by W1HDX and VE1SAT, the actual construction portion of the task was surprisingly easy. I'd like to describe the technique generally since it's usable with many rotors, and specifically with the two rotors I used.

Rotor Selection

If your computer is to turn the antennas, it needs three things: it must know where the antennas are pointing now, it must be told where they *should* be pointing, and it must be able to control the rotor motor and direction.

Any rotor I've ever worked with had some scheme to feed back position information to the control head. Some methods are easily adaptable to computers, some are not. When I went into this project, I had an az/el system using two TV rotors. After seven years of turning twenty elements on 435 MHz and twenty on 144 MHz, both rotors were a little tired. And, both had position information via a set of switch contacts in the rotor head which activated a solenoid in the control box. Yes, a computer *could* have been adapted to use this position system, but there would have been major drawbacks, not the least of which was the ten-degree maximum accuracy. I decided to replace both rotors.

The Station Controller computer board devised by AMSAT (now available through Snow Micro Systems[1]) includes circuitry (an analog-to-digital converter, usually referred to as A/D) which allows the computer to measure several external dc voltages. If position information can be presented to the computer board as a dc voltage within reasonable limits, the computer has available the current antenna position. The board also includes six computer-controlled relays, which could be used for rotor directional control. A search started for rotors using the dc voltage type of position feedback, which could be easily modified for computer control of on-off and direction switching.

---

[1] Snow Micro Systems, Inc., P.O. Box 1704, Silver Spring, MD 20902

*Author's address given on page 32.

The first rotor bought was the Ken-Pro KR-500 elevation rotor. Circuitry in the control head supplies a regulated voltage to a linear potentiometer in the rotor head. Once the rotor is aligned with the horizon, the pot's wiper, mechanically connected with the elevation axis, picks off a stable dc voltage which varies with antenna elevation. Ken-Pro uses the voltage to operate the control head meter calibrated in degrees. However, it can also be fed into a high-impedance input of the Station Controller Card, through a potentiometer to reduce the maximum voltage to 2 Vdc.

This rotor has direction switches mounted in the control head. External relays operated by the computer could be wired in parallel with the manual switches. All necessary points which must be reached by the computer are brought to the rear panel of the control head, except one: the hot side of the motor transformer. So, *total* modification to this rotor to allow computer control involved adding one wire inside the control head. Ken-Pro already provides an eight-terminal strip on the rear, but uses only six connections. A wire can easily be added between terminal seven and the side of the power transformer secondary which is not already brought out to the panel. Fig. 1 shows a simplified circuit diagram of this rotor, with the points where the wire is added indicated. Computer connections are made externally to the terminal strip, in parallel with the connections to the rotor head. No changes need to be made inside the rotor itself.

Azimuth, Too....

Next, a sturdy azimuth rotor was procured: the Alliance HD-73. A similar scheme for position indication is used by Alliance, except that the dc voltage used on the position pot is a little below what the computer would like to see. I made a small (and easily removed) modification to the voltage-supply circuitry to increase this voltage.

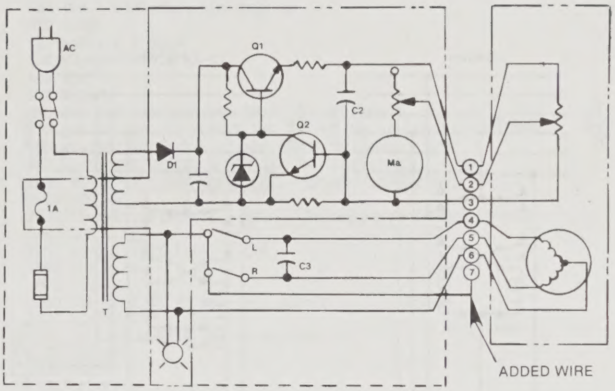

Fig. 1 · Circuit diagram of the commercially manufactured rotor. Component designations are those of the manufacturer. One wire needs to be added, as shown.

Fig. 2 shows a partial before-and-after diagram of the Alliance control head (again, no changes were made to the rotor motor). The jumper between terminals three and four inside the control head is removed. Both internal wires on these terminals (and later, both external wires from the rotor head) should be connected to terminal four. A wire is run from terminal three inside the control head, to the transformer side of the direction switch. Then, one end of the 82-ohm resistor is lifted from the circuit board. The Zener diode and resistor are added, and the wire going to terminal five is moved from the 82-ohm resistor junction to the new Zener-resistor junction. Lift the wire on terminal two and add a 2000-ohm resistor between that wire and the terminal. This brings the meter calibration into range of the front panel 'Calibrate' pot.

Now, both rotors are adapted for computer control. Note first, however, that *both rotors still function normally with hand control*. Even the external hookup of the rotors is unchanged, with one exception: when you connect the external wires, you should connect to terminal four of the HD-73 both of the rotor wires which Alliance shows going to terminals three and four.

Adding Computer Control

Now, what's necessary to enable the computer to get into the act? Only to run the position voltages from the terminal strips to the A/D inputs inside the computer, and connect the Station Controller board relays to

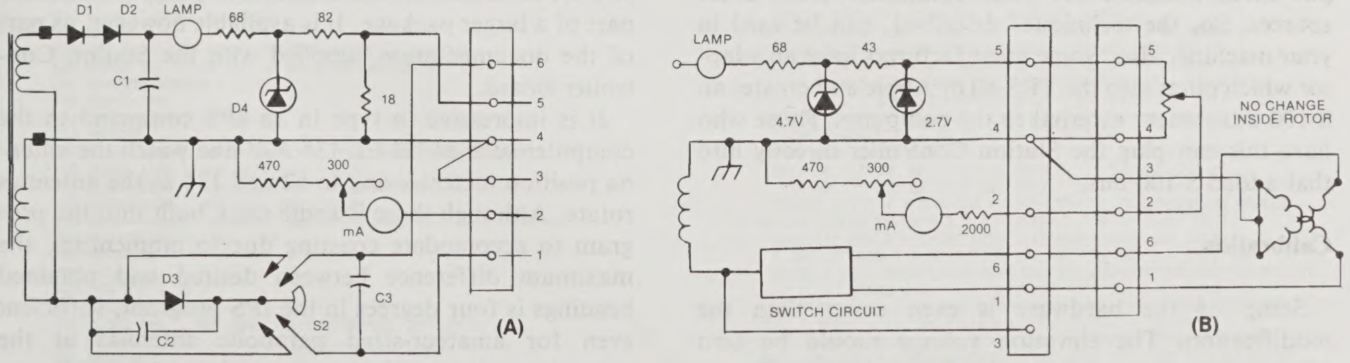

Fig. 2 · A partial before (A) and after (B) diagram of the azimuth rotor system.

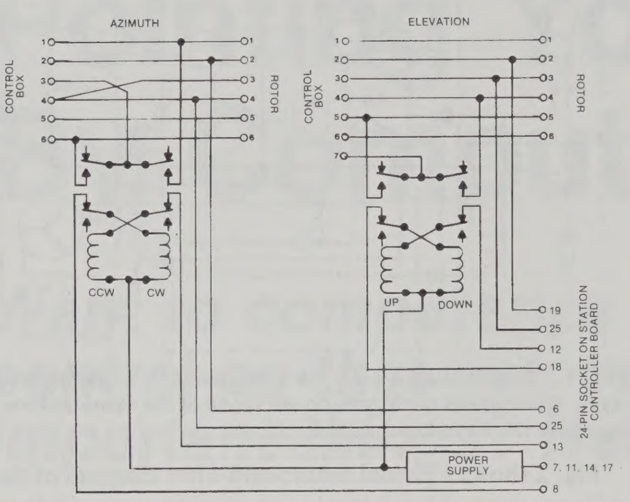

Fig. 3 · Final wiring interconnect between the computer and the rotor systems. See text for details.

switch the rotors. The small relays used on the Station Controller board are not designed to handle the heavy currents of the rotors, so they are used to drive external relays with higher current rating. Fig. 3 shows the final wiring of the interconnect between computer and rotor. I built a small interface box to hold the auxiliary relays, including some LEDs, to indicate when each rotor has its primary power switched on, and the direction of any computer-controlled antenna motion. Note that the added relays are cross-connected so that neither rotor can inadvertently be commanded to rotate in both directions at the same time by a hung-over computer (yes, computers do unexpected things sometimes). Leave out this step and you may someday have an aerial power resistor until your motor windings melt.

Incidentally, resist the temptation to derive the operating voltage for the auxiliary relays from the computer power supply. The inductive surge caused by the relay coils can cause problems in a sensitive computer.

I should mention that we've been talking about a type of computer called an S-100-bus computer, the only type which will accept the Station Controller card. For TRS-80 and Apple owners, there are A/D and relay output cards available for your computers from other sources. So, the techniques described can be used in your machine, also. Some manufacturers have an adaptor which plugs into the TRS-80 or Apple and creates an S-100 attachment external to the computer. Those who have this can plug the Station Controller directly into that added S-100 bus.

Calibration

Setup of the hardware is even easier than the modification. The elevation voltage should be zero when the antennas are pointed at the horizon, resting on the stop. Then, using hand controls, rotate the antennas upward to the vertical position. Adjust the control head pot so the meter reads 90 degrees. The voltage fed into the computer should be anything higher than one Vdc. Adjust the input potentiometer on the Station Controller board so that the voltage fed into the A/D chip is exactly one Vdc at ninety degrees elevation.

Azimuth voltage should be zero when the antennas are pointed South, rotated *counterclockwise* (viewed from above) into the stop. Then, using hand controls, rotate the antennas *clockwise* to the stop. Again, adjust the meter calibration pot to read 180 degrees. The voltage fed into the computer can be anything over two Vdc, and the potentiometer for this input should be adjusted to exactly two volts (1.999 if you are a purist and have a meter that can read that accurately). Whatever A/D you are using, make sure the chip calibration voltage is properly set or your readouts will be incorrect. The Snow board has a variable resistor (R3) to set that voltage.

That's it for the hardware portion of this effort. Going at it from scratch, the entire modification and construction is a one-weekend project. For once, my junk box yielded the few parts necessary (relays, box, and computer connector), so only the interconnecting cable had to be bought. Relay selection is not critical, but choose low-power ones with good contacts. Relays requiring heavy coil currents can weld the contacts on the small pcb relays on the computer card.

Software

Software to operate this function of the antenna board is available in several forms. The primary and most complete program is in the IPS language used by AMSAT's ground support stations. I have included a listing of W1HDX's IPS program. Those readers familiar with FORTH will be able to read it. In preparing this article, I wrote a similar program in NorthStar BASIC. Since the goal was to keep the two programs as similar as possible for ease of comparing, the listing reads somewhat ponderously in BASIC. It also runs a little slowly because of the many transfers of control. However, it will adequately demonstrate the functions of the antenna positioning uses of the Station Controller board.

There is also an assembly-language program to exercise the antennas. It runs much faster, and can be made part of a larger package. It is available however, as part of the documentation supplied with the Station Controller Board.

It is impressive to type in an IPS command to the computer such as '52 EL 134 AZ' and watch the antenna position meters swing to 52 and 134 as the antennas rotate. Although there is some slack built into the program to accomodate coasting due to momentum, the maximum difference between desired and obtained headings is four degrees in the IPS program, sufficient even for amateur-sized parabolic antennas at the microwave frequencies we may be using with our OSCARs a decade or so in the future.

It is even more impressive to run AMSAT's orbit prediction program based on W3IWI's program, which generates a table of az and el headings versus time (and also doppler shift, range to the satellite, and current position of the 'bird' in latitude and longitude). The computer then watches its clock (while doing other work for you), and automatically swings the antennas at the correct time. With this system, when the satellite is in range, you know without looking that your antennas are correctly pointed every minute. A one-armed paper hanger would really appreciate help like that.

SOFTWARE

```
10 REM BASIC PROGRAM TO SUPPORT AMSAT'S STATION CONTROLLER.
20 REM WRITTEN IN N* BASIC BY W6PAJ, BASED ON A PROGRAM IN
30 REM IPS LANGUAGE WRITTEN BY W1HDX.  THIS BASIC PROGRAM IS
40 REM WRITTEN AS SIMILAR AS POSSIBLE TO THE IPS PROGRAM AS
50 REM AN AID IN UNDERSTANDING IPS.     2 AUGUST 1980
60 REM ASSUMPTIONS - - - - - - - - - - - - - - - - - - - - -
70 REM STATION CONTROLLER BOARD ADDRESSED AT 20H.
80 REM AZIMUTH VOLTAGE ON CHANNEL 1, ZERO VOLTS AT 180
90 REM DEGREES CCW, 1 VOLT AT ZERO DEGREES, 2 VOLTS AT
100 REM 180 DEGREES CW.  ROTATION STOP AT SOUTH.
110 REM ELEVATION VOLTAGE ON CHANNEL 2, ZERO VOLTS AT
120 REM HORIZON, 1 VOLT AT 90 DEGREES (STRAIGHT UP).
130 REM RELAY OUTPUTS - 1, AZ CW, 8, AZ CCW
140 REM 2, EL UP, 4, EL DOWN.
150 REM - - - - - - - - - - - - - - - - - - - - - - - - -
160 A=32\B=A+1\C=A+2\D=A+3\REM BOARD PORT ASSIGNMENTS
170 T=0\D1=4\REM WIDTH OF AZIMUTH STOP IN DEGREES
180 DIM V(4) \ REM ARRAY FOR READING VOLTMETER DIGITS
190 OUT D,152\OUT B,64 \ REM INITIALIZE VM CHIP
200 GOSUB 600 \ REM GET PRESENT ANTENNA POSITION
210 PRINT"PRESENT ANTENNA DIRECTION: AZ ",Z2,"  EL ",L2
220 INPUT"AZIMUTH DIRECTION? ",Z1 \ REM GET NEW AZIMUTH
230 INPUT"ELEVATION ANGLE? ",L1 \ REM GET NEW ELEVATION
240 REM ———CHECK INPUT BOUNDS——————————————————
250 IF Z1 < 0 THEN Z1=0
260 IF Z1 > 360 THEN Z1=360
270 IF L1 < 0 THEN L1=0
280 IF L1 > 90 THEN L1=90
290 REM ———AZIMUTH ROTATOR LOOP———————————————
300 IF Z1=Z2 THEN 460 \ REM SKIP IF NEW AZ = OLD AZ
310 Z3=Z1-180\Z4=Z2-180\REM CHANGE COORD SO STOP IS AT NORTH
320 IF Z3<0 THEN Z3=360+Z3
330 IF Z4<0 THEN Z4=360+Z4
340 IF Z3>Z4 THEN 400
350 T=8 \ OUT B,T \REM START COUNTERCLOCKWISE
360 GOSUB 670 \ REM GET MOVING AZIMUTH
370 Z4=Z2-180 \ IF Z4<0 THEN Z4=360+Z4
380 IF Z4>(Z3+D1) THEN 360 \ REM WAIT TIL YOU GET THERE
390 OUT B,0 \ GOTO 460 \ REM TURN ROTOR OFF, GO TO ELEV
400 T=1 \ OUT B,T \ REM START CLOCKWISE
410 GOSUB 670 \ REM GET MOVING AZIMUTH
420 Z4=Z2-180 \ IF Z4<0 THEN Z4=360+Z4
430 IF Z4<(Z3-D1) THEN 410
440 OUT B,O \ REM TURN OFF AZIMUTH ROTOR
450 REM ———ELEVATION ROTATOR LOOP——————————————
460 IF L1=L2 THEN 1120 \ REM EXIT IF NO FURTHER CHANGES
470 IF L1>L2 THEN 550
480 T=4\REM SET FOR DOWN
490 OUT B,T \ REM TURN ON THE ELEVATION ROTOR
500 REM WAIT UNTIL ROTOR GETS THERE———————————————
510 GOSUB 630 \ REM GET ELEVATION READING
520 IF L2>(L1+D1) THEN 510
530 OUT B,0 \ REM TURN OFF ROTORS
540 GOTO 1120
550 T=2\OUT B,T\REM START UP
560 GOSUB 630 \ REM GET ELEVATION ANGLE
570 IF L2<(L1-D1) THEN 560
580 OUT B,0
590 GOTO 1120
600 GOSUB 630 \ REM GET ELEVATION ANGLE
610 GOSUB 670 \ REM GET AZIMUTH ANGLE
620 RETURN
630 OUT C,2 \ REM GETEL SELECTS VM CH 2, ELEVATION
640 GOSUB 730 \ REM GET VM READING AND CONVERT IT
650 L2=INT(V3*9/100 + 0.5)
660 RETURN
670 OUT C,1 \ REM GETAZ SELECTS VM CH 1, AZIMUTH
680 GOSUB 730 \ REM GET VM READING AND CONVERT IT
690 Z2=INT(V3*9/50 + 0.5)
700 Z2=Z2-180
710 IF Z2<0 THEN Z2=360+Z2
720 RETURN
730 GOSUB 1030 \ REM STARTS POSSIBLY INVALID CONVERSION
740 GOSUB 1090 \ REM WAIT FOR FINISH
750 GOSUB 1030 \ REM START VALID CONVERSION
760 GOSUB 1090 \ REM WAIT FOR FINISH
770 REM ———READ, CONVERT, AND STORE READING———————————
780 B6=INT(INP(A)/16) + 64
790 OUT B,B6
800 S=16
810 FOR N = 1 TO 3
820 S=S/2 \ OUT C,S
830 GOSUB 980 \ REM READ DIGIT, CONVERT, AND STORE
840 V(N)=V1
850 NEXT N
860 S=S/2 \ OUT C,S \ REM GET MOST SIGNIF DIGIT
870 V1=INT(INP(A)/8)
880 V2=2*INT(V1/2)
890 V1=V1-V2 \ REM ISOLATE MSD
900 N=4 \ V(N)=V1 \ REM SAVE IT
910 V3=0
920 FOR N = 1 TO 4
930 V3=V3+V(N)*10^(N-1)
940 NEXT N
950 RETURN
960 REM BIT MANIPULATION IS TOUGH WITH BASIC, BUT LET'S TRY!
970 REM WE HAVE TO SELECT AND INVERT THE LOW-ORDER FOUR BITS
980 V1=ABS(INP(A)-255) \ REM INPUT AND INVERT BITS
990 V2=16*INT(V1/16) \ REM ISOLATE HIGH-ORDER 4 BITS
1000 V1=V1-V2 \ REM LEAVE ONLY THE LOW-ORDER 4 BITS
1010 RETURN
1030 B6=INT(INP(A)/16) + 192 \ REM PDU PULSE DEVICE UPDATE
1040 OUT B,B6
1050 B6=INT(INP(A)/16) + 128
1060 OUT B,B6
1070 RETURN
1080 REM ROUTINE TO WAIT FOR END OF VM CONVERSION
1090 E1=INP(C)
1100 IF E1<128 THEN 1110 ELSE 1090
1110 RETURN
1120 PRINT
1130 GOTO 190
1140 END
```

```
        DAY 222/1980    1920:48 UTC    W6PAJ-G/C   (1)

(IPS PROGRAM TO POINT ANTENNAS WITH STATION CONTROLLER BOARD.  )
(ALLOWS SETTING ANTENNA AZIMUTH AND ELEVATION IN DEGREES BY    )
(COMPUTER.  ELEV VOLTAGE IS 0 AT 0 DEGREES, 1.0 AT 90 DEGREES, )
(AND 2.0 AT 180 DEGREES.  AZIMUTH VOLTAGE IS 0 AT 180 DEGREES  )
(WHERE STOP IS LOCATED, AND INCREASES CLOCKWISE FROM ABOVE TO  )
(1.0 VOLTS AT 0 DEGREES AND 2.0 VOLTS AT 180 DEGREES.  AZIMUTH )
(STOP IS ASSUMED TO BE +/- 4 DEGREES WIDTH.  ELEV VOLTAGE IS ON)
(A-TO-D CHANNEL 2, AZIMUTH VOLTAGE ON 1.  CONTROL RELAY USAGE  )
(IS #01 [RY-1] CW AZ, #02 [RY-3] EL UP, #04 [RY-4] EL DOWN,    )
(#08 [RY-6] CCW AZ.  TO SLEW, IPS COMMANDS ARE:                )
(<DESIRED EL> EL  <DESIRED AZ> AZ      W1HDX, VERSION 16 DEC 79)
  DEL/IF= AZEL
#20 CON PORTA  #21 CON PORTB  #22 CON PORTC  #23 CON CTLPRT
#10 CON ADRX     4 CON DEAD   #CF80 CON TV14
0 VAR VOLTS  0 VAR NEWAZ  0 VAR ELTMP  0 VAR AZTEMP  0 VAR DFF
0 VAR AZN  0 VAR TKPOS
20 FIELD AZDAT  20 FIELD ELDAT 20 FIELD TIMDAT  8 FIELD VOLTX

: PBOH #C0 AND PORTA RD 4 SHR #0F AND OR PORTB WRT ;  (PORTB HI)
: PBOL #3F AND PORTB WRT ; (PORTB OUTPUT LO GROUP, OPERATES RLY)
: BCDBNY DUP #0F AND SWAP #F0 AND 4 SHR 10 * + ;
: INITVM #98 CTLPRT WRT #7F PBOH ;
: EOC? LBEGIN PORTC RD #80 AND =0 LEND? ;   (END OF CONVERSION?)
: PDU #C0 PBOH #80 PBOH ; (PULSE DEVICE UPDATE ON A/D CONV CHIP)
: VMCNVRT 7 AND PORTC WRT PDU EOC? PDU ;
: SUM DUP S>R @ + R>S ! ;
: GETVOLTS #7F PBOH 1 4 EACH ADRX I SHR PORTC WRT PORTA RD INV
    #0F AND VOLTX I 1 - 2 * + !B NOW ;
: CVOLTS 0 VOLTS ! 1 3 EACH VOLTX I 1 - 2 * + @ BCDBNY 1 I
    EACH 10 * NOW 10 / VOLTS SUM NOW VOLTX 6 + @ INV 8 AND 3
    SHR 1000 * VOLTS SUM ;
: VMREAD EOC? GETVOLTS CVOLTS ;
: ANTOFF 0 PBOL ;                         (TURNS OFF ANTENNA RELAYS)
: ANTCW ANTOFF 1 PBOL ;             (ROTATE ANT AZIMUTH CLOCKWISE)
: ANTCCW ANTOFF 8 PBOL ;   (ROTATE ANT AZIMUTH COUNTERCLOCKWISE)
: ANTUP ANTOFF 2 PBOL ;                       (ROTATE ANTENNA UP)
: ANTDN ANTOFF 4 PBOL ;                     (ROTATE ANTENNA DOWN)
: GETIT VMCNVRT VMREAD VOLTS @ ;
: GETEL 2 GETIT 25 - DUP <0 YES? DEL 0 THEN 10 / ;  (ELEV DEGS.)
: GETAZ 1 GETIT DUP 1000 < YES? 18 * 10 / 1800 +
    NO: 1000 - 18 * 10 / THEN 10 / ;              (AZIMUTH DEGREES)
: ABS DUP >0 YES? NO: 0 SWAP - THEN ;
: EL DUP ELTMP ! <0 YES? 0 ELTMP ! THEN ELTMP @ 90 > YES? 90
    ELTMP ! THEN LBEGIN ELTMP @ GETEL > YES? ANTUP NO: ANTDN
    THEN ELTMP @ GETEL - ABS DEAD < LEND? ANTOFF ;
: P180 AZN @ 180 - NEWAZ ! ANTCW LBEGIN NEWAZ @ GETAZ - ABS
    DEAD < LEND? ANTOFF ;
: M180 AZN @ 180 + NEWAZ ! ANTCCW LBEGIN NEWAZ @ GETAZ - ABS
    DEAD < LEND? ANTOFF ;
: AZ AZTEMP ! LBEGIN GETAZ DUP AZN ! AZTEMP @ SWAP - DUP DFF !
    ABS DEAD < YES? (1) ANTOFF 1 NO: (1) DFF @ <0 YES? (2) DFF
    @ ABS 180 < YES? (3) AZTEMP @ 180 < YES? (4) AZN @ 180 >= 2
    + YES? (5) P180 NO: (5) ANTCCW THEN (5) NO: (4) ANTCCW
    THEN (4) NO: (3) ANTCW THEN (3) NO: (2) DFF @ ABS 180 <

       DAY 222/1980    1922:01 UTC    W6PAJ-G/C   (2)

   YES? (6)AZTEMP @ 180 > YES? (7) AZN @ 180 <= 2 + YES? (8)
   M180 NO: (8) ANTCW THEN (8) NO: (7) ANTCW THEN (7) NO: (6)
   ANTCCW THEN (6) THEN (2) 0 THEN (1) LEND? ;
: GETIM TIMEREAD 600 * SWAP 10 * + SWAP 6 / + (1/10 MINS) ;
: GRSP SP @ DUP 6 BLANKFIELD RESPONSE DEL REPLYCNV DEL ;
: FILLUP TV14 64 - SP ! " ENTER AZIMUTH DATA " 0 9 EACH TV14
   SP ! " AZ " I DEC CONV " : " GRSP AZDAT I 2 * + ! NOW TV14
   64 - SP ! " ENTER ELEVATION DATA " 0 9 EACH TV14 SP ! " EL "
   I DEC CONV " : " GRSP ELDAT I 2 * + ! NOW TV14 64 - SP !
   " ENTER UTC TIME ( HH MM SS ) " 0 9 EACH
   TV14 SP ! " UTC HH  " I DEC CONV "  :  " GRSP 600 *
   TV14 SP ! " UTC MM  " I DEC CONV "  :  " GRSP 10 * +
   TV14 SP ! " UTC SS  " I DEC CONV "  :  " GRSP 6 / +
   TIMDAT I 2 * + ! NOW CLR ;  (CONSTRUCTS TIME/POINTING TABLE)
: SETTER TIMDAT TKPOS @ 2 * + @ GETIM - DUP <0 (PAST SET?)
   YES? (1) ABS 1 > (MORE THAN 1/10 MIN?) YES? (2) TV14 SP !
   " END OF PASS " 3 DCHN THEN (2) NO: (1) ABS 1 < YES? (3)
   TKPOS @ 10 > YES? (4) 3 DCHN NO: (4) AZDAT TKPOS @ 2 * + @
   AZ ELDAT TKPOS @ 2 * + @ EL TKPOS INCR THEN (4) THEN (3)
   THEN (1) ;         (WAITS FOR NEXT TIMELINE, MOVES ANTENNAS)
: AZEL 0 TKPOS ! INITVM FILLUP 3 ICHN SETTER ;  INITVM
(FOR CLEANER NAMETABLE IF ACCESS ONLY TO <AZEL> CMND IS NEEDED,)
(INSRT <DEL/GROUP PORTA SETTER> AFTER AZEL DEF. BUT THE ROUTINE)
(HAS USEFUL UTILITIES.      AFTER EXECUTING <INITVM>, ANTUP/DN,)
(ANTCW/CCW & ANTOFF MAY BE USED FOR MANUAL CONTROL. ALSO, GETEL)
(AND GETAZ RETURN PRESENT POSITION OF ANTENNAS IN DEGREES.     )
```

Sporatic E Impact on Satellite Signals

Satellite transmissions are not completely immune from propagation disturbances, as described here.

By John Branegan, GM4IHJ*

During OSCAR 8's first six months of operation, the writer frequently noted severe attenuation and phase distortion on the Mode J downlink signals (*AMSAT Newsletter*, December 1978). Since then regular attention has been given to comparing general VHF propagation with disturbances on the satellite signals. Using any VHF satellites available together with the hundreds of easily identified terrestrial VHF TV and FM stations across Europe, a picture has emerged correlating the most frequent disturbance of satellite signals, with contemporary outbreaks of Sporadic E terrestrial VHF propagation. Disturbances are greatest on satellite frequencies at 145 MHz and below, but are also present to a lesser degree at 435 MHz. The following is a report of a typical summer day disturbance: Saturday, 28 June, 1980, location Saline, Fife, Scotland at 56°N 3°W.

Early Morning At 0705Z the writer switched on the DX TV receiver to find a steady clear Sporadic E propagated picture already locking on Channel E2. The signal at 48.254 MHz was from Gruten in Southern Germany, and over the next hour it was joined by signals from South West Russia, Switzerland, Italy and Spain. All channels up to 70 MHz were locking firm video from these stations in the range bracket of 600 to 1200 miles and between azimuths 110° and 180°.

At 0820Z, GM4JYZ called me on two meters to ask how good my TV pictures from Spain were. He reported that signals from the NOAA 6 weather satellite had been dropping out completely as it passed over Madrid and he knew from previous problems of this sort, that when the weather boys got scratchy pictures, this writer got TV pictures from areas of roughly the same azimuth.

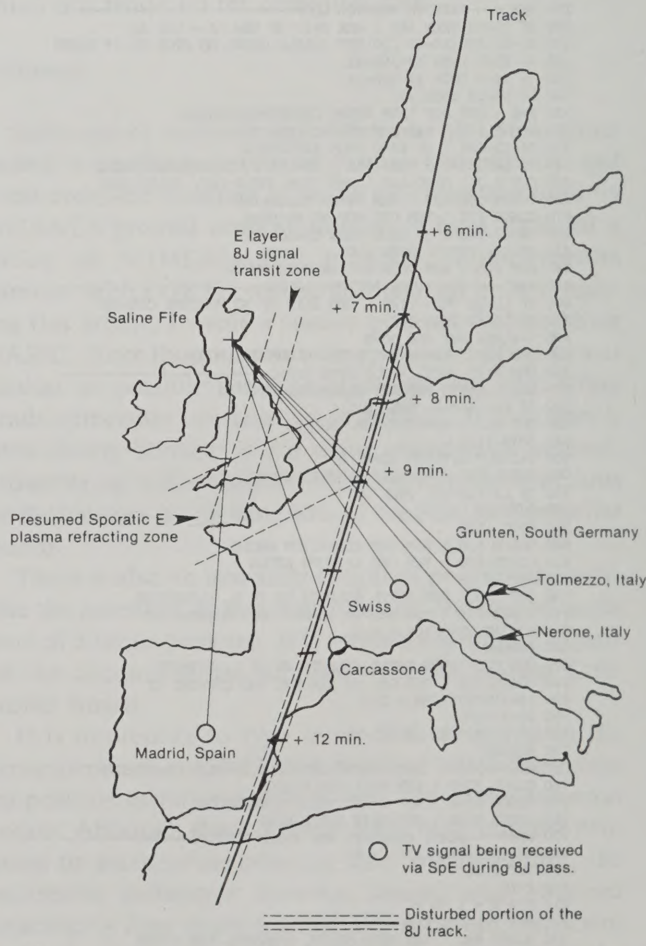

Fig. 1 - Satellite track and the location of TV stations received via sporatic E propagation.

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*Author's address given on page 32.

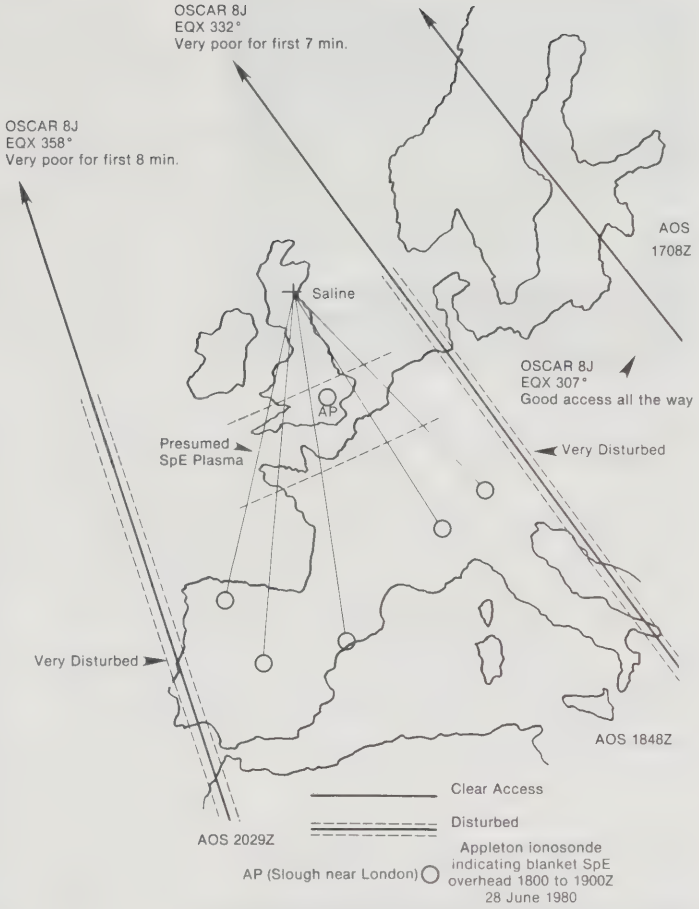


Fig. 3 · Disturbed Mode J orbits and sporatic E as noted during the evening of June 28, 1980. Note the areas which are very disturbed.

Midmorning At 0850Z OSCAR 8 was due to come up (in Mode J) over the North Cape, Norway passing to the east of Scotland and going out to the south over Morocco Africa. The writer accessed the satellite easily and had two good QSO's before fading completely, half way through the third QSO as the satellite line of sight approached the Sporadic E zone. Though the beacon was heard thereafter, access on 145 MHz was not satisfactorily achieved before loss of satellite at the horizon. Fig. 1 shows the satellite track and the location of the TV stations received via Sporadic E. Fig. 2 shows a graph of my Mode J downlink and the beacon signal strength. Note how the 435.1 MHz beacon is less affected than the two-way transionospheric 145 MHz uplink and 435.45 MHz downlink.

Afternoon During the afternoon strong TV and FM signals at frequencies up to 100 MHz were coming into Scotland from azimuths of between 135° and 200° *i.e.* from Italy to Portugal. None of the OSCAR 7 Mode B or OSCAR 8 Mode J passes cut across or behind this region. Only one of the seven orbits tracked had any propagation disturbance on it—this was OSCAR Mode J which was badly disturbed. For this writer it is a very regular feature of high polar passes—a disturbance when the satellite passes between Scotland and the north geomagnetic pole.

Evening With Sporadic E TV still coming in strongly from all across the southeast quadrant, OSCAR 8 Mode J signals were once again very disturbed while the satellite line of sight from Scotland cut through the E-layer plasma zone. Three good QSO's were achieved after the satellite had cleared the disturbed zone. But firm consistent access was impossible while the satellite was viewed through the E-layer plasma. See Fig. 3.

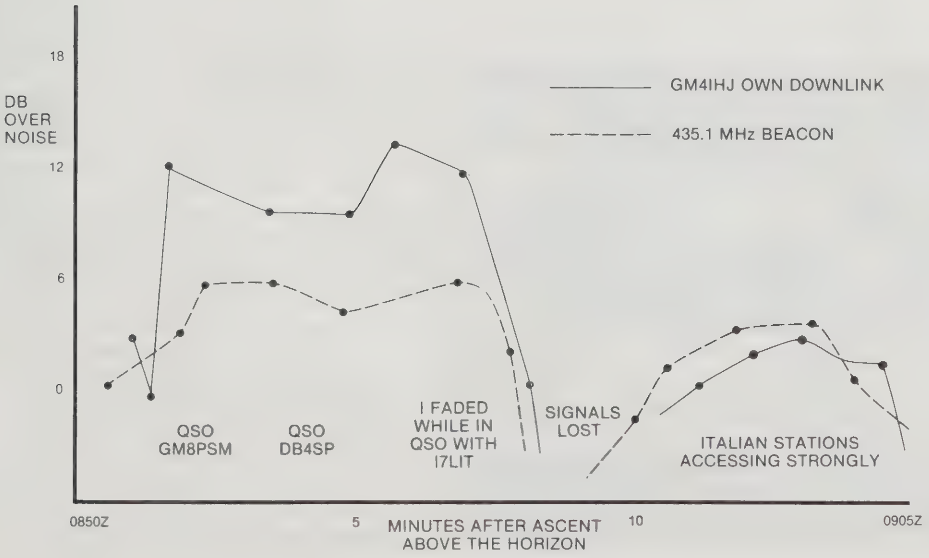
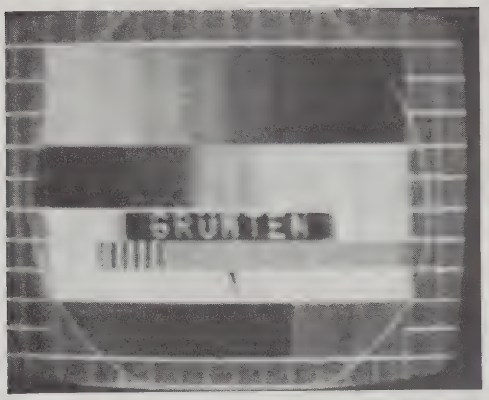
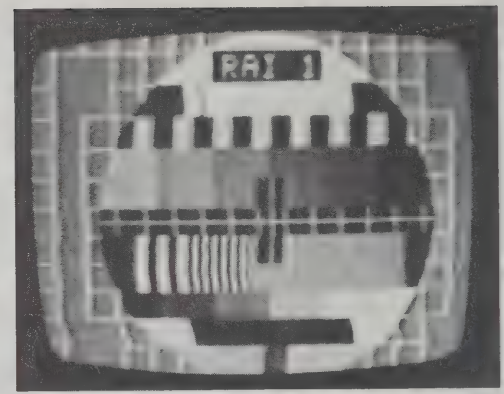


Fig. 2 · Mode J downlink and beacon signal strengths as recorded June 28, 1980.



◄ Fig. 4A · Very poor Mode J signal during the early hours of July 14, 1979, concurrent with good signals from Grunten, Germany on 48 MHz.

Fig. 4B ► Poor Mode J signals on July 22, 1979 along with good signals from an Italian TV station on 62 MHz.



Tests at other times The writer has carried out tests both when Sporadic E was present, and when it was absent. At no time has this type of satellite signal degradation been consistently observed except when Sporadic E was present on the same azimuth bearing or close to it. Stations to the northwest, northeast, east, southeast and south have been checked concurrently with satellite orbits. All of these bearings have at one time or another produced Sporadic E signals as shown in Fig. 4. Concurrent disturbances of satellite signals at the same azimuth as the Sporadic E cloud, appear to be a regular feature.

Fig. 4C · A Soviet sports show is bad news for Mode J during the p.m. hours of May 24, 1980.

Summary It would appear that E-layer plasma with electron density sufficient to refract or scatter propagate terrestrial signals up to frequencies of 70 to 100 MHz, can be associated with conditions which seriously disturb satellite signal links at much higher frequencies. Signals at 137 or 145 MHz, whether they be up or down links, are more seriously degraded than 435 MHz signals. Checks on satellite P76 up to August 1979 revealed that signals at 1239 MHz were hardly affected at all.

In Scotland, there are, in an average year, about 130 days on which Sporadic E layer propagation can be detected. Roughly half of these days feature events long enough in duration and suitably placed to interfere with at least one OSCAR orbit, thereby constituting a considerable nuisance. It would be of interest to know whether these conditions apply elsewhere in the world.

Should anyone be tempted to conclude that the problems noted here are more probably a fault of OSCAR 8 Mode J or the choice of up and downlink frequencies for this satellite, the writer hastens to point out that OSCAR 8 Mode J features strongly here simply because it is the most consistent of the amateur satellites. OSCAR 7 Modes A and B, and OSCAR 8 Mode A are also affected by Sporadic E, but they are also affected by so many other things that it is difficult to get any consistent picture from their performance. Hence their omission from this discussion.

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Comets

OUR COVER

Our cover this month shows Ron Dunbar, W0PN, with the portable AMSAT-GOLEM-80 microcomputer that he carried to Marburg, Germany in 1978. He and Karl, DJ4ZC, spent several weeks together converting the cassette based 1802 IPS language into an 8080 version. The computer chassis was designed to sit flat inside a suitcase for easy transportation. The front panel includes an I/O port as well as the reset switch. Ron has since spent two years enhancing IPS and developing Phase III tracking and control software in IPS.

WORLDWIDE SATELLITE ACTIVITY

By Pat Gowen, G3IOR*

The past Summer months have been a relatively quiet time on the satellites for a number of reasons. AMSAT-OSCAR 7 was still crossing the terminator and going into the earth's shadow (eclipse) at 60°S, and would go completely dead until it recrossed the terminator, came back into sunlight the solar-cells picked up sufficient energy to give enough voltage to render the transponders and beacon active again. Until the end of July, Mode B was operating, but only when the satellite was in sunlight. Now the clock is changing the mode daily and both modes are sounding excellent. Some problems are evident when high-power stations are using Mode B. Symptoms of high-band noise, ALC attenuation, and Oscillator pulling producing QRI on cw and garbling on ssb are a few of them.

The 'A' modes of both AMSAT-OSCAR's 7 and 8 suffer some degree of attenuation on the downlink caused by heavy ionization during the present solar-cycle peak. The incursion of fm users into the ten-meter downlink band often causes problems too, in addition to harmonics from commercial stations. As AMSAT-OSCAR 8 was on Mode J each Saturday and Sunday, and AMSAT-OSCAR 7 was set in Mode B, no experiments on the daylight scatter paths were possible. Summer holdiays and the chance to enjoy outside pursuits, undoubtedly had their effect upon activity, as well as prior attention by those who were preparing their stations for Phase IIIA. In spite of the above, lots of devotees continued their operations through both satellites in all modes, with several new stations appearing. There was a dire shortage of any new countries showing up to help those bordering on their OSCAR-DXCC's.

It is optimistically expected that with earlier and darker evenings now due in the Northern Hemisphere, attenuation will decrease and activity will be on the upswing again producing a greater variety of stations. What is more, October will undoubtedly bring a recurrence of the Auroral zone plasma density increase, to give us multi-path OSCAR access and extended horizons of downlink audibility similar to those of late 1979.

An interesting account of this phenomena, assistive to those wishing to participate in its investigation, is given by John Branegan, GM4IHJ, following a Solar flare event that took place at 0930 on January 8, 1980. John recorded the following results on the following day, with an AMSAT-OSCAR 8 Mode J orbit of 1134 UTC 222°W equatorial emanation.

At 1159 UTC, with the satellite at 024° Azimuth and 0° elevation, beacon heard.

At 1159.30, 023° Az, 2° El, marker placed on uplink carrier on two meters. The resultant downlink was split, with direct signal 559 on 70 cm and with a further slightly auroral signal at 5 and 4, 2.7 kHz higher in frequency.

At 1201, 017° Az, 7° El, no echoes or secondary downlinks could be heard from either the ON7VHF beacon, or from a DL station, but firm echoes were present on his own marked signal.

At 1202, 009° Az, 10° El, firm echo still present on his signal.

AT 1202.40, 007° Az, 12° El, echo faded abruptly and no further echoes were heard until 1209, and for the next minute, with satellite at 275° Az, 17° El, echoes could be heard faintly on his signal, on ON7VHF, and DL1JV, all 500 Hz above the direct downlink signal.

At no time during the above test could echoes be heard from the beacon, evidencing that the refraction was entirely upon the two meter uplink, and no effects were observed upon the following orbit. The evidence gained was that a clear association exists between optimum sun-angle, solar flare production, hence ion density, and two meter refraction propagation.

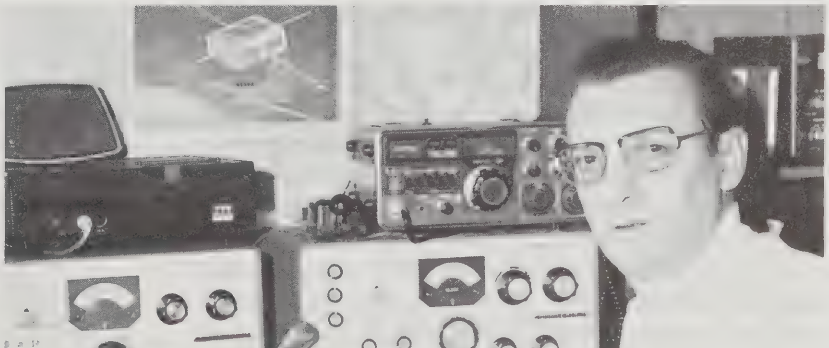
John recorded another similar event at 0702 UTC on July 18, when he was simultaneously monitoring the 435.095 MHz Mode J beacon and his own downlink to get an idea of the total electron count along the line-of-sight to the satellite. He discovered a further return 400 Hz higher and much broader in bandwidth than his straight returned downlink. John related: 'as I went to check Dopplers, HG8CY called me, also with double signals, so we actually had a quartet going when both transmitting.' The effect ceased at 0707. The beacon had been single signal throughout, but, at four minutes before true AOS, it was heard as a broad band signal for some 10 seconds. It would be worth the while of those experiencing this phenomena to make a direct schedule on two meters with their transatlantic contact just to try the direct two-meter path at these times.

On the SDX front, the following West Coast stations might like to know that we in Europe are hearing good signals from them, but QSO's are rather more elusive....W5VVR, W6DWN, N6DD, W7MKN, W7UFE, W7FF, all Mode A cw.

The July Aaland Island and Market reef OSCAR-dx-pedition by OH1KB, PE1BWX and PD0EEZ have ON6NL as OSL manager. QSL's for The Isle of Man DX-pedition on OSCAR by GD4CUO/P go to Dave, G4CUO QTHR. QSL direct for 6W8IA to Hartmut Schlinke, P.O. Box 387, St. Loise, Senegal.

Finally, some possible 'firsts' on OSCAR in RTTY QSO's....February 11, 1980, AMSAT-OSCAR 7 Mode B, VE2QO and VE2TY, first VE/VE RTTY OQSO. February 29, 1980, AMSAT-OSCAR 7 Mode B, VE2QO and G3PEJ, believed to be first transatlantic OSCAR RTTY QSO, subject to any earlier claims.

Finally, congratulations to Nick, W0CA, who in late August 1980 made the very first OSCAR Worked All Continents (WAC), a feat thought impossible without the Phase III orbit! His contacts were CN8AU for Africa, K0GA for North America, HC1BI for South America, G3IOR for Europe, KH6IBA for Oceania, and UA0BBN for Asia. Nick's well earned, special plaque was presented by Bernie Glassmeyer, W9KDR, of the ARRL at the AMSAT General Meeting on September 13, 1980.



DL3SX shown here at his operating position.

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*Author's address given on page 32.

The Third Generation

The first part of this series appeared in the September/October issue. Here, the author describes further, the developments which have made a significant contribution to the Amateur Satellite program.

By Jan King, W3GEY*

The Phase IIIA transponder continued in the tradition of AMSAT-OSCAR's 6 and 7 by improving the state-of-the-art in linear transponder technology, in that a number of significant advances were made compared to the Mode B transponder of AMSAT-OSCAR 7.

It is necessary to review the status quo to appreciate the comparison. The 70 cm-to-two-meter transponder carried on the AMSAT-OSCAR 7 spacecraft has an output power of just about 10 watts PEP. Transponder automatic gain controls were established to maintain the peak-to-average-power ratio at 4:1. The average rf output is then 2.5 watts. Using the Envelope Elimination Restoration (EER) Principle the power amplifier chain has an efficiency of about 50 percent. The bandwidth (3 dB points) is 43 kHz. The spacecraft typically can be accessed by users up to a range of about 3500 km (2200 mi.) give or take various odd propagation modes occurring near AOS and LOS.

Recalling that the Phase IIIA spacecraft was to attain an apogee of 35,000 km and would be in view of a large percentage of the world's amateurs for most of the time, improvements in power output and passband bandwidth were in order. To achieve signal levels comparable to those of AMSAT-OSCAR 7, near AOS, some 20 dB increase in EIRP on the downlink would be necessary:

$$\text{dB difference} = 20_{\log} \left[\frac{35{,}000\text{km}}{3{,}500\text{km}}\right] = 20$$

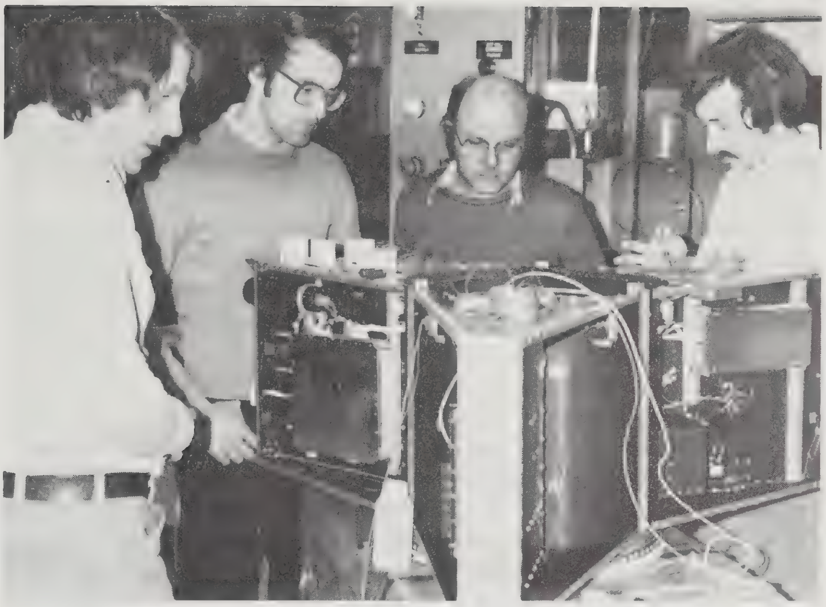
The desired bandwidth to accomodate the worldwide user community would have been quite large. However, practical limitations (*e.g.* worldwide two-meter frequency allocation and passband filter realization) set this limit at somewhat under 200 kHz. Considering beacon requirements and doppler shift, a 150 kHz bandwidth seemed a reasonable goal. A major portion of the additional path loss as compared to AMSAT-OSCAR 7 was to be made up by antenna gain at the Phase IIIA spacecraft. Both up and down link 'high gain' antennas achieved a minimum gain of + 10 dBi. This left 10 dB to be made up by the transmitter on the downlink. Because of constraints on available dc power, only seven dB of the desired improvement could be realized. The transmitter PEP output was set then at 50 watts giving a downlink EIRP of 500 watts (some 3 dB short of the overall goal). This downlink level was considered by the designers to be quite an acceptable compromise. The user is left with the option of increasing his receive antenna gain by 3 dB (with only a small pointing penalty) or simply accepting this lower signal level which is within the normal user system 'error plus uncertainty' budget. In fact, with a circularly polarized antenna at the ground and at the spacecraft the Phase III user picks up most of the 3dB due to matched polarization, an improvement over the non-optimum AMSAT-OSCAR 7.

When comparing Phase III to AMSAT-OSCAR 7, uplink path loss increases are also an additional 20 dB. Again + 10 dBi of antenna gain on 435 MHz was planned and achieved. While slight improvements in front-end noise figure were accomplished with the new transponder and total input noise was reduced because of the greater distance of the earth from the satellite, some seven to nine dB of additional uplink power would have been required by Phase IIIA users to achieve similar results to AMSAT-OSCAR 7. In effect, this has the advantageous effect of reducing the ability of 'big gun' stations to overload the transponder by the same seven to nine dB! The increased transponder bandwidth also reduces the sharing problem since a strong station will have to share with many more stations.

Transponder Technology

It is important to review the existing in-orbit technology of AMSAT-OSCAR 7. New users may not be aware of what they are using right now, others may need a refresher. In order to transpond a portion of

*AMSAT Vice-President, Engineering.



Preparing the Phase IIIA Spacecraft for Thermal Vacuum testing. Standing left to right are W3GEY, DK4VW, DJ4ZC, and K1JX

spectrum from one frequency to another where frequency sharing techniques are employed a linear amplifier must be used to maintain both the phase and amplitude relationships of the original signals and to avoid undesireable intermodulation products. It is known that linear amplifiers exhibit poor dc to rf power conversion efficiency resulting primarily from the bias point of the amplifier. This implies that a quiescent current will be drawn independent of drive level. Class A, AB and B amplifiers typically have *peak* efficiencies from 20 to 50 percent. To make efficiency matters much worse, the amplifier is seldom driven to peak values. In the case of our satellites, the drive signal is a summation of amplitude modulated signals (cw, ssb, other). This 'ensemble' of signals obeys statistical laws in accordance to a property known as the central limit theorem. The significance of this is that the average power output of the ensemble is about seven dB below the peak level in a real system. A classical linear amplifier has, in fact, very poor efficiency at these drive levels (between five and 20 percent under ideal conditions). Clearly, such amplifiers cannot be tolerated in a satellite design where dc power is such a precious resource.

I now introduce a principle which I truely feel can be attributed to Karl Meinzer, DJ4ZC: simply stated, it is possible to increase the efficiency of a linear amplifier beyond its 'classical' theoretical maximum if the amplifier source voltage is reduced in accordance with (*i.e.* proportionally with) the input drive signal.† The converse is also true. This is clearly evident. The inefficiency of classical linear amplifiers can be traced to the percentage of time that the drive signal is low and the plate or collector supply remains constant. In fact, it is possible to achieve amplifiers that have a nearly constant and high efficiency over a wide range of drive levels. This is precisely the desired performance for our needs. This class of amplifiers is sometimes referred to as 'Class-D' although there is some confusion over the definition of what should be included here. See Fig. 6.

There are a number of approaches to the design of such an amplifier to be sure. As you might suspect, a number of performance tradeoffs result from any specific design candidate. In the transponder aboard AMSAT-OSCAR 7 the EER concept originated by L. Kahn was adopted by DJ4ZC for the Mode B power amplifier. Fig. 7 shows this concept. At i-f a sample of the drive signal is envelope detected and amplified. The main amplifier chain consisting of Class-C amplifiers operates on the i-f signal after it has passed through a limiter. In fact, two separate channels have been created. The one containing the Class-C amplifiers contains only the phase information from the original signal while the second 'envelope' channel contains only the original amplitude information. The original signal is recreated, in fact, when the envelope component, after suitable linear amplification, is used to modulate the last few amplifier stages in the phase channel. High-efficiency linear and drive-independent performance may be obtained using an EER amplifier providing that phase delay between the two channels is minimal and that certain requirements of the envelope amplifier are met. It is the characteristics of the envelope amplifier that are the main 'trick' to the transponder. DJ4ZC found that it was important that the bandwidth of the envelope amplifier (referred to as simply the modulator) be from three to five times the i-f or passband bandwidth and that this linear amplifier itself must be of a high efficiency type lest it degrade the overall amplifier efficiency. To accomplish this a switching duty factor amplifier was employed. The envelope signal was fed to a high power switching circuit which produced a rectangular output whose duty factor was proportional to the amplitude of the envelope during a given sample period. The object of the saturated switch was that it dissipates no power except during switching transitions and thus, is inherently very efficient. The duty factor waveform was finally put through a low-pass filter to recover the original envelope at high level for the modulation process. With a 10-watt transponder using an i-f bandwidth of 45 kHz, the demands placed on the modulator were stringent but achievable. A minimum modulation bandwidth of 150 kHz is required and the amplifier was required to switch two-ampere peaks in a few nanoseconds so as to minimize switching periods. In 1973 when the AMSAT-OSCAR 7 transponder was built, the solid-state devices to accomplish this latter task reliably had only just become available.

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†To be more precise the performance of the amplifier may be improved by the desired amount by manipulating any output parameter (*e.g.* dynamic impedance) such that the power source to the amplifier is drive dependent.

The Phase III transponder requirements of 150 kHz bandwidth and 50 watts PEP output proved to be a bit too much for this type of amplifier. Now the modulator bandwidth became about 500 kHz and switching currents as high as ten amperes in even fewer nanoseconds became a requirement. While some devices were found that would handle this problem, long term reliability still remained a concern. When a modulator of this form was tested the most serious problem, however, turned out to be the incredibly high level of rfi generated by the very fast switching action. Attempting to remove this 'hash' from the remainder of the system has proved futile to date.

The solution to this problem was to develop an entirely different amplifier which is a *first* as a space application. Another approach to solving the high efficiency amplifier problem was introduced by W.H. Doherty in 1936.[8] The Doherty amplifier also 'obeys' the Meinzer Theorem. Consider the concept shown in Fig. 8. A single transistor amplifier is utilized so that it is operating at high effeciency when driven to a level corresponding to the average power output of the passband envelope (or approximately six to seven dB below peak value). The transistor can be operated at high efficiency at any particular output power provided that the collector voltage swing is large. Put differently, the load impedance must be high enough to require a large voltage output from the device. If we take the requirements of the Phase III amplifier as an example, a device capable of delivering 25 watts into an impedance of Ƶ ohms at high efficiency, will deliver 12.5 watts into 2Ƶ ohms at the same voltage output and thus the same efficiency. The problem with this arrangement is that upward modulation peaks would not be amplified because the collector swing has already reached its maximum value at 12.5 watts output.

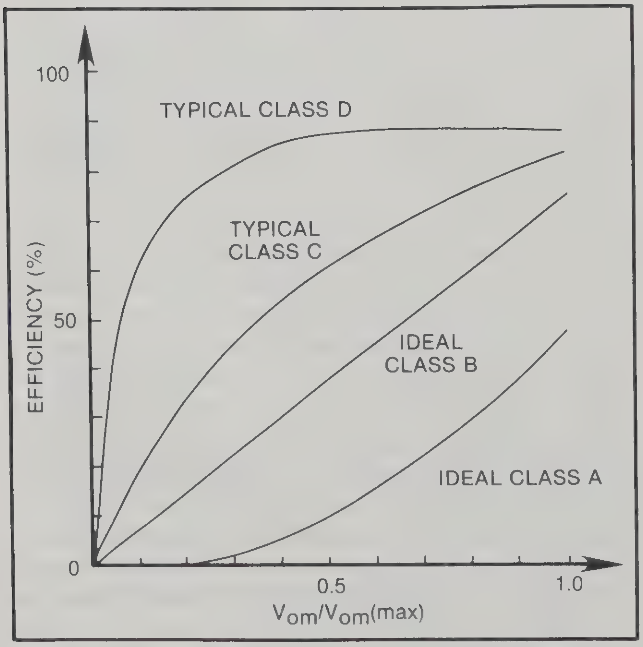


Fig. 6 - Efficiency of Class D power amplifiers remains high down to relatively low output levels. (From Raab[9]).

At this point Doherty proposed that an additional and variable source of voltage be inserted in series with the load impedance (Fig. 8B). The additional source is to have a peak value equal to the output voltage of the first device and its amplitude is to increase as the drive increases above the average value. The primary purpose of this voltage generator is to handle the transponder modulation peaks. At peak drive now, the current increases to twice the average value as does the voltage. Consequently the power increases from the average value of 12.5 watts to 50 watts or by six dB. It is interesting to note that the effect experienced by the original transistor as the added generator comes into play is a gradual lowering of the impedance into which it is operating, since its output current increases without an increase in output voltage. In fact, when the generator output reaches its maximum value, the circuit impedance has exactly been reduced from 2Ƶ to Ƶ ohms.

The problem now remaining in the output circuit is to synthesize a realizable voltage generator. We cannot directly replace the ideal generator with a typical active device because, while a generator would offer no impedance to the flow of current from the original transistor, an active device, when turned off offers a very high impedance. What is required is an impedance transformer that has an impedance at the source port that is inversely proportional to the terminating impedance on the output port. This is a well known property of a quarter-wave transmission line. It turns out that a ¼ wavelength coax line possesses all of the desired characteristics for such a scheme and is convenient to implement in the case of a 145 MHz amplifier. The generator device then becomes an identical rf amplifier to that of the original amplifier. At ¼ drive (the average output) the first amplifier is delivering all of the output. As the drive increases the first and second amplifier begin to share the load. At full output each amplifier is furnishing ½ of the output power which is twice the average power level.

Some additional consideration must be given to the input circuitry of the amplifier. While in Doherty's case, 'the grids of both tubes are excited by the modulated

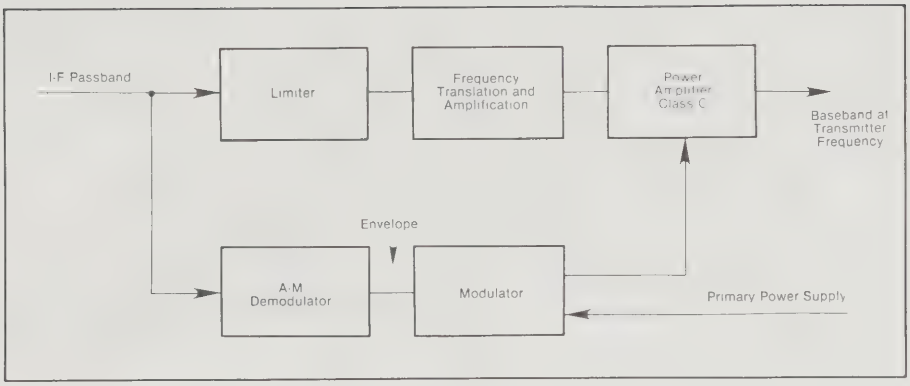


Fig. 7 · The envelope elimination and restoration process.

output of the preceding stage' (keep in mind the date of his work) with appropriate bias conditions, the Phase III transponder again makes use of EER technology to accomplish the modulation function. Each of the two amplifiers have two stages of gain. The driver stages are fed with the phase component of the signal while the envelope component is applied to the collectors of the driver stages via two different non-linear networks that produce amplifier transfer characteristics as shown in Fig. 10A. The effect of the networks are, of course, to produce the correct bias conditions for amplifier power sharing as described above.

In Fig. 9 one notes a few auxiliary design requirements of the EER-Doherty amplifier. A 90° phase shift of the input to one amplifier is necessary to compensate for the 90° shift at the output of the other amplifier created by the quarter-wave transmission line. The square law networks following the non-linear bias network in the modulator chain and the feedback around the amplifier are both used to improve overall amplifier linearity. The 37.5-ohm ¼ wavelength line is used to match the low output impedance of the amplifier to a 50-ohm load.

The performance of the flight EER-Doherty amplifier was excellent. Fig. 10C shows the efficiency as a function of drive level. This efficiency curve is typical of Doherty amplifiers. Note that below the average power point the efficiency drops off rapidly while above this level it is fairly constant.

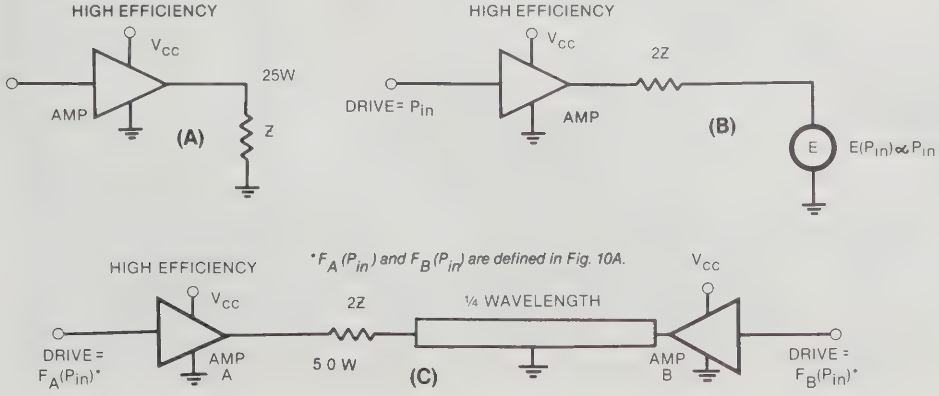
Fig. 11 shows the flight transmitter including the two amplifier components and modulation circuitry of the EER-Doherty amplifier. Thus a technology intended for improving the efficiency of 'multikilowatt' a-m broadcast transmitters finds its use today in providing a new solution to communications via satellite—something perhaps Doherty would never have dreamed of.

Antenna System

Unlike the transponder development some parts of the antenna system early on defied analytical resolution. In order to get a feeling for the likely antenna patterns for Phase III a computer analytical model was constructed. The model allowed for the 'construction' of any array of dipole elements at arbitrary angles with respect to one another and would predict the antenna pattern viewed in the far field by an observer with either a circular or a linearly polarized antenna. One thing that could not be accounted for, however, was the reflective properties of the structure itself. A number of important design considerations were learned from the model:

A. The preferred two-meter high-gain antenna (two elements at the end of each arm) was found to have a gain of 9.5 dBi which was in close agreement with hand calculations done earlier.

B. It was found that the 70 cm (435 MHz) high-gain antenna could not be placed on the end of the arms. Having three antennas with such widely separated phase centers created big side lobe problems and consequently a high degree of spin modulation. It became necessary to explore placing a 70-cm array on top of the structure with



*$F_A(P_{in})$ and $F_B(P_{in})$ are defined in Fig. 10A.

Fig. 8 · Doherty Amplifier Concept. See the text for more details.

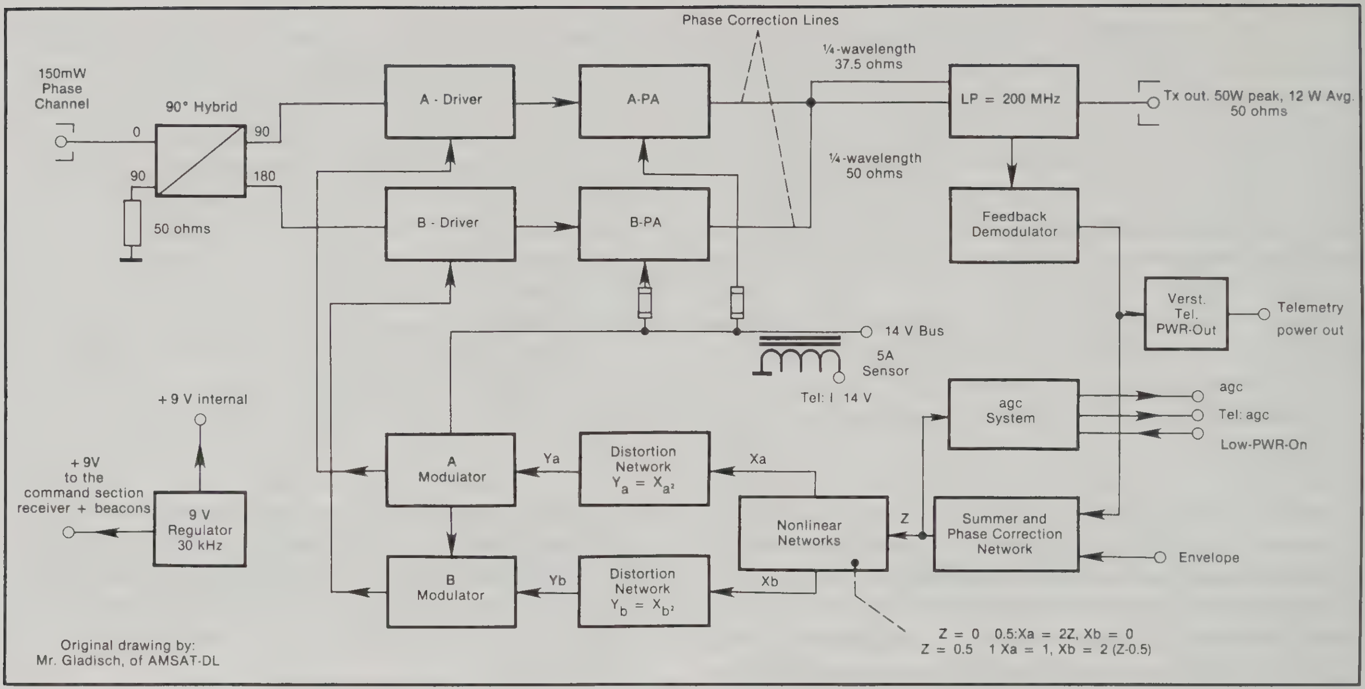


Fig. 9 - Phase III Transponder EER - Doherty Amplifier/Modulator Block Diagram.

elements closer to the spin axis. The model predicted good performance for this configuration.

C. For both high-gain antennas the model predicted acceptable spin modulation (less than 3 dB) out to 45° off the spin axis *provided* that the users utilized circularly polarized antennas.

D. As predicted, the 120° geometry of the antenna system had no drawbacks concerning the ability to produce a circularly polarized wave with good axial ratio.

As one might have guessed, the hard realities of the antenna range produced some rather painful surprises. While the 70-cm array behaved very well from the onset and conformed well with predictions, the two-meter array problem virtually defied solution. It was discovered that no arrangement of antennas on the end of the arms would produce a forward lobe with sufficient gain and symmetry. Two properties of the structure became evident:

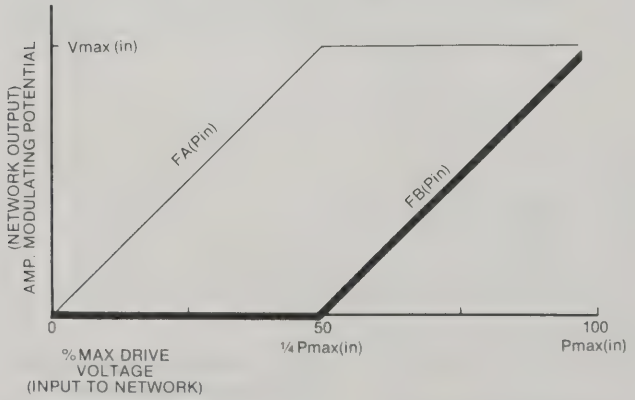


Fig. 10A - Modulation Network Transfer Characteristic.

A. As might be predicted, the structure was a poor image plane primarily because of its small size compared to a wavelength at two meters.

B. Any substantial antenna currents flowing along the sides of the arm (*i.e.* in the solar panel substrates) tended to produce a lobe approximately normal to the spin axis. This is probably because the two adjacent panels form a sort of corner reflector.

After some five months of intermittant development time, a configuration was found that produced acceptable results. It was determined that if a driven element was placed on top of each arm, near the end and at an angle of 30° with respect to the top surface, a very nice beam was formed off the back of the spacecraft. By inserting a passive reflecting element on the end of the arm near the bottom, it became possible to turn this beam around to form a symmetric forward lobe with higher gain. The problem remaining was that three strong side lobes were created each 120° apart in azimuth and 60° away from the spin axis. After many attempts, no solution could be found that would attenuate the side lobes without affecting the main lobe as well. In practice, the side lobes would have caused no serious problems since we only planned on using this antenna to 40° off the spin axis where the spin modulation performance was still acceptable. However, it was unfortunate that a better solution was not found. The actual mode of operation of the antenna is still not well understood and resulted in the error made in polarization sense announced before launch. The two-meter antenna exhibits such a clear reversal of beam direction when the reflectors were added that it was assumed that a true reflection was occurring off of the bottom elements. When a circularly polarized wave is reflected from a conducting surface its polarization sense is also

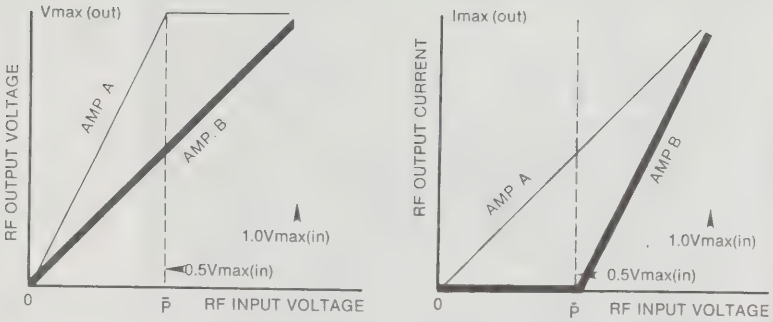


Fig. 10B · Voltage and current relations in the two amplifiers.

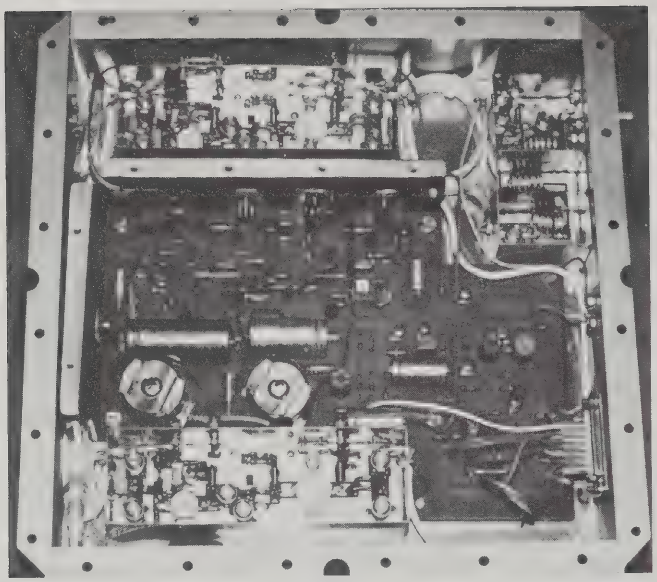
reversed: thus left hand circular polarization (LHCP) becomes right hand circularly polarized (RHCP). It was assumed then, that if the driven elements were fed LHCP that the beam would be RHCP. By the time it was realized that we were not sure about this property it was too late to make measurements on the range. We used our best judgement and made the flight cables for LHCP. And as everyone knows by now, the Phase IIIA two-meter high-gain antenna does not reverse its polarization sense. Again my apologies to all of those who had to reverse their antennas in the cold of last winter. In some sense *you have now shared in the headaches of developing a spacecraft.*

Now that the two meter antenna worked, it was assumed that all was complete. Wrong again! The elements protruded well above the top surface of the spacecraft and since the spacecraft was mounted 'sideways' on the launcher, two of the elements were touching the fairing (nose cone) of the launcher. The three top elements had to be reduced to 85 percent of a quarter-wavelength and new matching networks designed to handle the odd impedance.

Fortunately, the omnidirectional antennas had fewer development problems. From the start, the two-meter antenna patterns were almost perfect utilizing only a simple monopole mounted on top of the structure. What came as a real surprise was that while a deep null was expected off the back of the spacecraft, instead a shallow and broad null was observed. This would have greatly improved performance of the satellite near perigee. The excellent rotational symmetry of the antenna was also a pleasant surprise. See Fig. 12.

The 70-cm omni antenna was a sleeved dipole mounted with its phase center 28.5 cm (11.2 in.) above the structure on the spin axis. Thus, portions of it were in common with the two meter monopole. This combined antenna also had to be shortened to assure that it would fit within the fairing. Patterns for the 70-cm omni antenna were as predicted.

The AMSAT Phase III Team pictured at a design review in October 1978. Standing: W4PUJ, Peter Bell, VE1SAT, W1HDX, VE2VQ, W3IWI, DJ4ZC, WD4FAB, and W3PK. Kneeling: G3ZCZ, K2UBC, VK3ZZF, W3GEY, and W0PN.



In all, the Phase IIIA communication system included the transponder, ten antenna elements, two three-way power splitters, eight rf relays, two filter modules, one diplexer filter, four matching networks and 15 coax cables (most were silver plated semirigid cables using SMA connectors).

Acknowledgement

My thanks to Karl Meinzer, DJ4ZC, for his assistance in preparing this section. As most are aware, Karl and AMSAT-DL are responsible for the design and construction of the transponder. Full acknowledgements of all Phase III participants will be included in a subsequent issue of *ORBIT* Magazine.

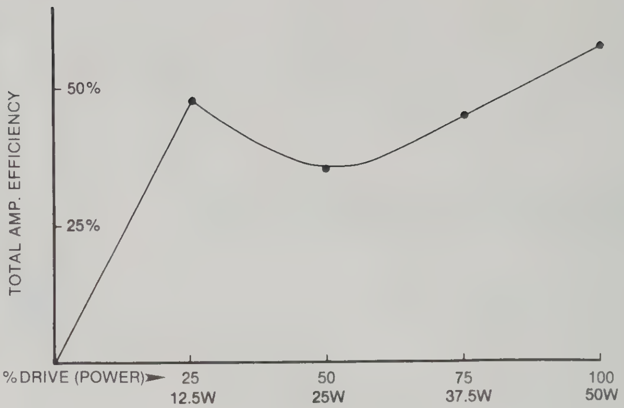


Fig. 10C (above) - Total amplifier efficiency as a function of drive level.

Fig. 11 (left) - AMSAT Phase IIIA EER-Doherty Amplifier Module.

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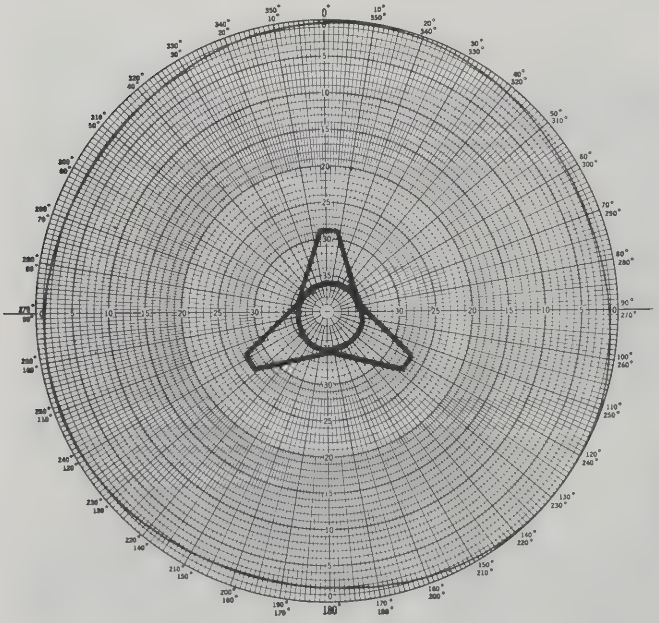

Fig. 12A - Two-meter omni spin modulation at 90° from the spin axis (in spin plane). Chart calibration is given in dB.

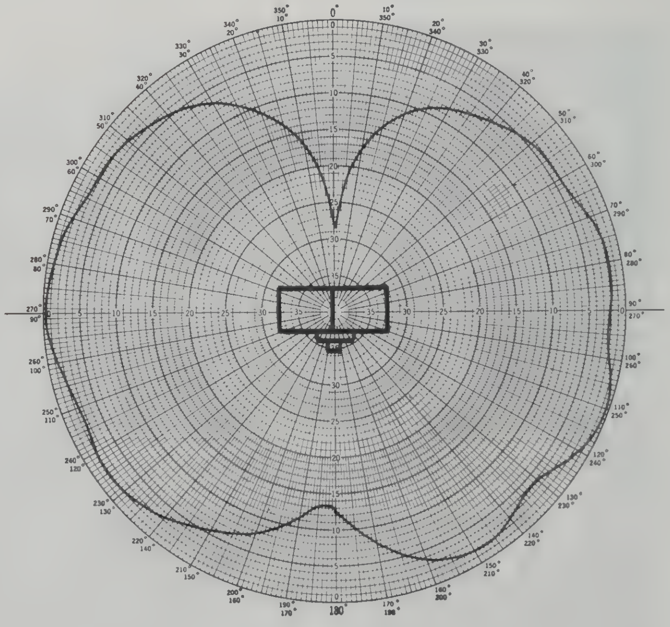

Fig. 12B - Two-meter omni elevation antenna pattern. Chart calibration is given in dB.

SATELLITE LOG

By Geoffrey Falworth*

Satellite Log features launches into orbit since the beginning of 1980. The satellite name is that assigned by the launching agency (the international designation is in parenthesis) and the orbit (period, inclination to Earth's equator, apogee height, perigee height) is for shortly after launch; later maneuvers may modify this orbit. Transmissions are those which are publicly reported or assumed from the type of spacecraft involved.

Cosmos 1176 (1980-34A) launched on 1980 Apr 29; initial orbit: 89.66 min, 65°.02, 266 km, 250 km; transmissions: None reported. High-resolution low-altitude reconnaissance and surveillance satellite, possibly nuclear powered.

Cosmos 1177 (1980-35A) launched on 1980 Apr 29; initial orbit: 89.68 min, 67°.15, 346 km, 174 km; transmissions: none reported. Maneuverable 44-day reconnaissance satellite.

Cosmos 1178 (1980-36A) launched on 1980 May 7; initial orbit: 90.38 min, 72°.85, 386 km, 200 km; transmissions: none reported. Recoverable reconnaissance satellite.

Cosmos 1179 (1980-37A) launched on 1980 May 14; initial orbit: 103.60 min, 82°.97, 1552 km, 303 km; transmissions: none reported. Possible geodetic or ionospheric research satellite.

Cosmos 1180 (1980-38A) launched on 1980 May 15; initial orbit: 89.82 min, 62°.82, 286 km, 246 km; transmissions: none reported. Recoverable reconnaissance satellite.

Cosmos 1181 (1980-39A) launched on 1980 May 20; initial orbit: 104.99 min, 82°.95, 1009 km, 977 km; transmissions: 150.000 MHz. Navigation satellite.

Cosmos 1182 (1980-40A) launched on 1980 May 23; initial orbit: 89.14 min, 82°.34, 251 km, 211 km; transmissions: none reported. Recoverable reconnaissance and Earth resources satellite.

Soyuz 36 (1980-41A) launched on 1980 May 26; initial orbit: 90.09 min, 51°.62, 350 km, 313 km; transmissions: 20.008 MHz, 121.750 MHz. Manned spacecraft (crew: Valeri Kubasov, commander and Bertalan Farkas, flight engineer) docked with Salyut 6 on 1980 May 27.

Cosmos 1183 (1980-42A) launched on 1980 May 28; initial orbit: 92.54 min, 72°.90, 419 km, 378 km; transmissions: none reported. Recoverable reconnaissance satellite.

NOAA 7 (1980-43A) launched on 1980 May 29; initial orbit: 102.12 min, 92°.23, 1448 km, 267 km; transmissions: 136.770 MHz, 137.500 MHz, 137.620 MHz, 137.770 MHz, 1698.000 MHz, 1702.500 MHz, 1707.000 MHz. Weather satellite; booster engine malfunction prevented nominal orbit insertion; spacecraft inoperable.

Cosmos 1184 (1980-44A) launched on 1980 Jun 4; initial orbit: 97.43 min, 81°.24, 647 km, 623 km; transmissions: none reported. Military weather satellite.

Soyuz T2 (1980-45A) launched on 1980 Jun 5; initial orbit: 90.27 min, 51°.60, 315 km, 266 km; transmissions: 20.008 MHz, 121.750 MHz. Manned spacecraft (crew: Yuri Malyshev, commander and Vladimir Aksenov, flight engineer) docked with Salyut 6 on 1980 Jun 6.

Cosmos 1185 (1980-46A) launched on 1980 Jun 6; initial orbit: 89.49 min, 82°.33, 282 km, 213 km; transmissions: none reported. Recoverable reconnaissance and Earth resources satellite.

Cosmos 1186 (1980-47A) launched on 1980 Jun 6; initial orbit: 94.55 min, 74°.02, 519 km, 473 km; transmissions: none reported. Electronic surveillance satellite.

Cosmos 1187 (1980-48A) launched on 1980 Jun 12; initial orbit: 89.69 min, 72°.85, 291 km, 227 km; transmissions: 19.989 MHz. Recoverable reconnaissance satellite.

Gorizont 4 (1980-49A) launched on 1980 Jun 14; initial orbit: 1436.05 min, 0°.80, 35831 km, 35747 km; transmissions: 3695 MHz, 3745 MHz, 3795 MHz, 3845 MHz, 3895 MHz, 3945 MHz. Communications satellite at Statsionar 4 location over 14° West.

Cosmos 1188 (1980-50A) launched on 1980 Jun 14; initial orbit: 725.54 min, 62°.92, 40129 km, 609 km; transmissions: 2292 MHz. Early warning satellite.

Meteor 35 (1980-51A) launched on 1980 Jun 18; initial orbit: 97.24 min, 97°.93, 667 km, 584 km; transmissions: 137.300 MHz. Weather satellite.

Operations 3123 (1980-52A) launched on 1980 Jun 18; initial orbit: 88.79 min, 96°.46, 257 km, 167 km; transmissions: none reported. Reconnaissance satellite.

Operations 1292 (1980-52C) launched on 1980 Jun 18; initial orbit: 112.32 min, 96°.63, 1333 km, 1331 km; transmissions: none reported. Electronic surveillance satellite.

Molniya 77 (1980-53A) launched on 1980 Jun 21; initial orbit: 737.68 min, 62°.83, 40703 km, 631 km; transmissions: 800 to 1000 MHz, 3400 to 4100 MHz. Molniya 1 class communications satellite.

Cosmos 1189 (1980-54A) launched on 1980 Jun 26; initial orbit: 89.55 min, 72°.88, 305 km, 198 km; transmissions: none reported. Recoverable reconnaissance satellite.

Progress 10 (1980-55A) launched on 1980 Jun 29; initial orbit: 88.91 min, 51°.62, 264 km, 183 km; transmissions: 166.000 MHz, 922.750 MHz. Cargo and supply spacecraft; docked with Salyut 6 on 1980 Jul 4.

Cosmos 1190 (1980-56A) launched on 1980 Jul 1; initial orbit: 100.86 min, 74°.04, 806 km, 792 km; transmissions: none reported. Military data relay satellite.

Cosmos 1191 (1980-57A) launched on 1980 Jul 2; initial orbit: 725.41 min, 62°.67, 40127 km, 605 km; transmissions: 2292 MHz. Early warning satellite.

Cosmos 1192 (1980-58A) launched on 1980 Jul 9; initial orbit: 114.61 min, 74°.02, 1476 km, 1398 km; transmissions: none reported. Military communications satellite.

Cosmos 1193 (1980-58B) launched on 1980 Jul 9; initial orbit: 117.73 min, 74°.02, 1684 km, 1473 km; transmissions: none reported. Military communications satellite.

Cosmos 1194 (1980-58C) launched on 1980 Jul 9; initial orbit: 114.82 min, 74°.01, 1479 km, 1414 km; transmissions: none reported. Military communications satellite.

Cosmos 1195 (1980-58D) launched on 1980 Jul 9; initial orbit: 115.41 min, 74°.02, 1477 km, 1470 km; transmissions: none reported. Military communications satellite.

Cosmos 1196 (1980-58E) launched on 1980 Jul 9; initial orbit: 115.63 min, 74°.02, 1494 km, 1473 km; transmissions: none reported. Military communications satellite.

Cosmos 1197 (1980-58F) launched on 1980 Jul 9; initial orbit: 115.84 min, 74°.02, 1510 km, 1475 km; transmissions: none reported. Military communications satellite.

Cosmos 1198 (1980-58G) launched on 1980 Jul 9; initial orbit: 116.08 min, 74°.02, 1533 km, 1475 km; transmissions: none reported. Military communications satellite.

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*Author's address given on page 32.

A Packet Network Simulator

Use a Pascal program on your own computer to develop strategies for the design of a satellite-based packet radio network. And you don't even need a satellite!

By Hank Magnuski, KA6M*

Prior to the launch of the Phase IIIA last May, an effort was started to define and publish specifications for the AMSAT International Computer Network, AMICON. The unfortunate delay in the Phase III program gives us an opportunity to perform the substantial amount of design work and planning needed to implement a satellite-based packet radio digital communications network prior to the launch of Phase IIIB. It is inevitable that such a network will come into existence sometime during the next five years and its long distance communications power will be superior to the complementary terrestrial repeater links which probably will also develop.[1]

Designing a packet network protocol is a tough problem because there are many degrees of freedom and the solution to the problem cannot be stated using simple mathematical results. Twenty or thirty independently acting stations cannot be put on a breadboard to verify and test different strategies. What can be done, though, is to simulate network activity using a computer model of the net and to implement the rules and regulations of operation in programmed subroutines and procedures. This method permits different designs and algorithms to be checked at very little cost and can give one insight into the characteristics of network operation.

The author, being part of the AMICON design group, started studying the technical literature on satellite packet radio nets for information on the best protocol to use. Good work in this area has been done in recent years, and there is a rapidly expanding body of literature. Unfortunately, none of the articles deal adequately with two of the main constraints of our network: the narrow bandwidth available and the need to keep equipment simple and at a low cost. In an effort to better understand the operation of a packet radio network and to verify some of the proposals suggested for AMICON, a PASCAL program was written to simulate the operation of a multi-station satellite packet radio network. This program is described here and may be modified by others to test their own proposals for satellite or ground based repeater networks. The results of initial simulation runs are already giving us good pointers to follow for the design of the net, and more complete results will follow.

Simulating the Network

This simulator is a discrete event state simulator. This means that simulation real time is divided into small time periods, typically 50 milliseconds. At the beginning of each time period certain control variables which represent the state of the network are recomputed based on what happened in the immediately preceding time period. Once computed these control variables are fixed and are not subject to change during the remaining portion of the current time period. Next, the state of each station in the network is adjusted as required by the current values of the control variables. The activity of each station also may be influenced by picking a number from a random number generator. When all of the individual station variables have been updated, some final processing is done, the clock is incremented and the cycle begins once again. Thus, we get continuing snapshots of network activity based on 50 millisecond increments, a short time period in comparison to the total length of a complete simulation run, which may last 500 to 1000 seconds. The 50 millisecond interval was chosen because it allows five clock ticks to occur during the time it takes a radio signal to make a round trip through the Phase III satellite transponder at apogee.

This simulator includes a delay line so that events at a transmitter do not affect a receiver until the 250 millisecond signal delay has passed. This delay could be shortened or eliminated, permitting the program to serve as a basis for studying terrestrial repeaters as well.

*Author's address given on page 32.

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Start of Packet Network Simulation
N=20 T=  10. maxpkt=127 bps= 1200. pn=1.000 pr= .050 ptraffic= .010
  Time  -  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
    .00 -
    .05 -
    .10 -
    .15 -                 N                             N
    .20 -                 N*                            N*
    .25 -                 N*                            N*
    .30 -                 N*                            N*
    .35 -                 N*                            N*
    .40 -                 N*                            N*
    .45 -                 .                             .
    .50 -                 .                             .
    .55 -                 .                             .        N
    .60 -                 .                             .        N
    .65 -                 .                             .        N
    .70 -                 .                             .        N*
    .75 -                 .                             .        N*
    .80 -           N     .                             .        N*
    .85 -           N*    .     N                       .        N*
    .90 -           N*    .     N*                      .        N*
    .95 -           .     .     .                       .        N*
   1.00 -           .     .     .                       .        N*
   1.05 -           .     .     .                       .        N*
   1.10 -           .     .     .                       .        .
   1.15 -           .     .     .                       .        .
   1.20 -           .     .     .                       .        .
   1.25 -           .     .     .                       .        .
   1.30 -           .     .     .                       .        .
   1.35 -           .     .     .                       .        .
   1.40 -           .     .     .                       .        .
   1.45 -           .     .     .                       .        .
   1.50 -           .     .     .                       .        .
   1.55 -           .     .     .                       .        .
   1.60 -           .     .     .                       .        .
   1.65 -           .     .     .     N                 .        .
   1.70 -           .     .     .     N*                .        .
   1.75 -     N     .     .     .     N*                .        .
   1.80 -     N*    .     .     .     N*                .        .
   1.85 -     N*    .     .     .     N*                .        .
   1.90 -     N*    .     .     .     N*    N           .        .
   1.95 -     .     .     .     .     N*    N           .        .
   2.00 -     .     .     .     .     N*    N           .        .
   2.05 -     .     .     .     .     .     N           .        .
   2.10 -     .     .     .     .     .     N           .        .
   2.15 -     .     .     .     .     .     N           .        .
   2.20 -     .     .     .     .     .     N           .        .
   2.25 -     .     .     .     .     .     N           .        .
   2.30 -     .     .     .     .     .     N*          .        .
   2.35 -     .     .     .     .     .     N*          .        .
   2.40 -     .     .     .     .     .     N*          .        .
   2.45 -     .     .     .     .     .     N*          .        .
   2.50 -     .     .     .     .     .     N*          .        .
   2.55 -     .     .     .     .     .     N*          .        .
   2.60 -     .     .     .     .     .     N*          .        .
   2.65 -     .     .     .     .     .     N*          .        .
   2.70 -     .     .     .     .     .     N*          .        .
   2.75 -     .     .     .     .     .     N*          .        .
   2.80 -     .     .     .     .     .     N*          .        .
   2.85 -     .     .     .     .     .     N*          .     N  .
   2.90 -     .     .     .     .     .     N*          .     N  .
   2.95 -     .     .     .     .     .     N*          .     N  .
   3.00 -     .     .     .     .     .     V           .     N  .
   3.05 -     .     .     .     .     .     V           .     N  .
   3.10 -     .     .     .     .     .     V           .     N  .
   3.15 -     .     .     .     .     .     V           .     N  .
   3.20 -     .     .     .     .     .     V           .     N  .
   3.25 -     .     .     .     .     .                 .     N* .
   3.30 -     .     .     .     .     .                 .     N* .
   3.35 -     .     .     .     .     .                 .     N* .
   3.40 -     .     .     .     .     .                 .     N* .
   3.45 -     .     .     .     .     .                 .     N* .
   3.50 -     .     .     .     .     .           N     .     N* .
   3.55 -     .     .     .     .     .           N     .     N* .
   3.60 -     .     .     .     .     .           N     .     N* .
   3.65 -     .     .     .     .     .           N     .     N* .
   3.70 -     .     .     .     .     .           N     .     N* .
   3.75 -     .     .     .     .     .           N     .     N* .
   3.80 -     .     .     .     .     .           N     .     N* .
   3.85 -     .     .     .     .     .           N     .     V  .
   3.90 -     .     .     .     .     .           N     .     V  .
   3.95 -     .     .     .     .     .           N     .     V  .
   4.00 -     .     .     .     .     .           N     .     V  .
   4.05 -     .     .     .     .     .           N     .     V  .
   4.10 -     .     .     .     .     .           N*    .        .
   4.15 -     .     .     .     .     .           N*    .        R*
   4.20 -     .     .     .     .     .     N     N*    .        R*
   4.25 -     .     .     .     .     .     N*    N*    .        R*
   4.30 -     .     .     .     .     .     N*    N*    .        R*
   4.35 -     .     .     .     .     .     .     N*    .        .  N
   4.40 -     .     .     .     .     .     .     .     .        .  N
   4.45 -     .     .     .     .     .     .     .     .        .  N
   4.50 -     .     .     .     .     .     .     .     .        .  N
   4.55 -     .     .     .     .     .     .     .     .        .  N
   4.60 -     .     .     .     .     .     .     .     .        .  N
   4.65 -     .     .     .     .     .     .     .     .        .  N*
   4.70 -     .     .     .     .     .     .     .     .        .  N*
   4.75 -     .     .  N  .     .     .     .     .     .        .  N*
   4.80 -     .     .  N* .     .     .     .     .     .        .  N*
   4.85 -     .     .  N* .     .     .     .     .     .        .  N*
   4.90 -     .     .  .  .     .     .     .     .     .        .  N*
   4.95 -     .     .  .  .     .     .     .     .     .        .  N*
   5.00 -     .     .  .  .     .     .     .     .     .        .  N*
   5.05 -     .     .  .  .     .     .     .     .     .        .  .
   5.10 -     .     .  .  .     .     .     .     .     .        .  .
   5.15 -     .     .  .  .     .     .     .     .     .        .  .
   5.20 -     .     .  .  .     .     .     .     .     .        .  .
   5.25 -     .     .  .  .     .     .     .     .     .        .  .
   5.30 -     .     .  .  .     .     .     .     .     .        .  .
   5.35 -     .     .  .  .     .     .     .     .     .        .  .
   5.40 -     .     .  .  .     .     .     .     .     .        .  .
   5.45 -     .     .  .  .     .     .     .     .     .        .  .
   5.50 -     .     .  .  .     .     .     .     .     .        .  .
   5.55 -     .     .  .  .     .     .     .     .     .        .  .
   5.60 -     .     .  .  .     .     .     .     .     .        .  .
   5.65 -     .     .  .  .     .     .     .     .     .        .  .
   5.70 -     .     .  .  .     .     .     .     .     .        .  .
   5.75 -     .     .  .  .     .     .     .     .     .        .  .
End of Network Simulation
Station:  1 Packets=   0 Collisions=    0 Delay=    .00 Bytes sent=     .
Station:  2 Packets=   1 Collisions=    1 Delay=   6.60 Bytes sent=   56.
Station:  3 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station:  4 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station:  5 Packets=   0 Collisions=    2 Delay=    .00 Bytes sent=     .
Station:  6 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station:  7 Packets=   0 Collisions=    0 Delay=    .00 Bytes sent=     .
Station:  8 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station:  9 Packets=   1 Collisions=    1 Delay=    .05 Bytes sent=    8.
Station: 10 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station: 11 Packets=   0 Collisions=    0 Delay=    .00 Bytes sent=     .
Station: 12 Packets=   1 Collisions=    1 Delay=    .40 Bytes sent=  103.
Station: 13 Packets=   0 Collisions=    0 Delay=    .00 Bytes sent=     .
Station: 14 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station: 15 Packets=   1 Collisions=    0 Delay=    .30 Bytes sent=  111.
Station: 16 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station: 17 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .
Station: 18 Packets=   1 Collisions=    0 Delay=    .40 Bytes sent=   88.
Station: 19 Packets=   0 Collisions=    2 Delay=    .00 Bytes sent=     .
Station: 20 Packets=   0 Collisions=    1 Delay=    .00 Bytes sent=     .

Summary of Network Activity

  Channel efficiency = 24.40%
  Channel duty cycle = 49.50%
```

Fig. 1 · Packet Network sample test run.

The PASCAL Program

The simulation program was written in PASCAL, a computer language which has become very popular in the personal computing field. PASCAL's ability to define scalar types and procedures permits the construction of a very compact and readable program for this simulation application. The main body of the program consists of a single 'while' statement which calls on several larger procedures to do the real computation. The program was written and tested on a Data General Eclipse minicomputer, and there should be very little trouble in transporting the program to other minis or micros. The following paragraphs give more details on the implementation.

The main procedure in the program is found at the end of the listing and consists of a ten-line 'while' statement. The 'while' statement reads through a file of parameters which establishes control values for a given simulation run. Each line of the input file generates a complete simulation, which consists of one call to the 'initialize' procedure, repeated calls to the 'nextstate' procedure, and a single call to the 'finalize' procedure.

The 'initialize' procedure reads and prints the parameters for the current run, and then resets channel control variables, the channel delay line, and all the variables associated with each station. Each station in the network is represented by a PASCAL record of type 'node.' The 'node' contains the entire history of past activity at the station and its current state. There is no other information kept about individual stations.

The 'nextstate' procedure is called at each tick of the clock, and its operations may be divided into three main sections. First, it looks at the signal delay line and sets the 'channel' variable to reflect the state of the signal being received from the satellite. Next, it looks at the

```
{Packet Network Simulation Program   --------   Written by H. S. Magnuski, KA6M}

program net(input,output);

const maxstations = 20;         {Maximum number of stations in the simulation}
      tick = 0.050;             {Time interval between state changes}
      tdelay = 0.250;           {Delay time for signal round trip to satellite}
      delaycount = 5;           {Number of clock ticks in round-trip delay}

{The following record contains all control variables required for each station}

type node = record state:(nopkt,newpkt,oldpkt,verpkt);  {State of the station}
                   xmtr:(off,on);              {State of the transmitter}
                   packetsize:integer;         {Number of bytes in packet}
                   newpkttime:real;            {Generation time of new packet}
                   xmtpkttime:real;            {Transmit start time of packet}
                   endpkttime:real;            {Transmit end time of packet}
                   verdelay:0..delaycount;     {Verification delay counter}
                   totalpkts:integer;          {Total packets sent by station}
                   totalhits:integer;          {Total packet collisions}
                   totaltraffic:real;          {Total number of bytes sent}
                   totaldelay:real;            {Total time packets waited}
            end;

var time : real;                               {Clock time during simulation}
    trun : real;                               {Length of this simulation run}
    nstations : 1..maxstations;                {Number of stations in run}
    i : 1..maxstations;                        {Index for stations}
    station : array [1..maxstations] of node;  {Storage for all station nodes}
    rcvsignal, xmtsignal :integer;             {Signal descriptors}
    channel : (inactive,active,conflict);      {Channel activity descriptor}
    chnltime : real;                           {Channel in-use time}
    chnlusers : integer;                       {Channel users at any instant}
    chnldelay : array [1..delaycount] of integer; {Channel delay shift register}
    k : 1..delaycount;                         {Channel delay counter}
    maxpkt : integer;                          {Maximum packet size in bytes}
    maxpkttime : real;                         {Maximum packet transmit time}
    bpsrate : real;                            {Bits-per-second rate}
    pn, pr, ptraffic : real;                   {Transmit probabilities}
    seed : integer;                            {Random number generator seed}
    print : 1..3;                              {Print verbosity control}

{This function returns a real random number in the range 0.0 to 1.0.
 It is provided as an external system call in this PASCAL.
 Users may have to write their own random number generator if their PASCAL
 system does not supply such a procedure.}

function random (var seed: integer) : real; external;

{The 'nextpacket' procedure is used to generate new traffic at each station.
Changes in how often a station comes up with a new packet and how large the
packet will be can be implemented here. The procedure presented below uses
a threshold variable, ptraffic, which will increase or decrease traffic
loading, and then sets the packet size to a value based on the maximum
packet length.}

procedure nextpacket (var site: node);
begin if random(seed) < ptraffic then
        begin
         site.packetsize := trunc(random(seed)*maxpkt);
         site.newpkttime := time;      {Traffic generation time}
         site.state := newpkt;         {New state, packet traffic available}
        end;
end; {nextpacket}

{The reschedule procedure implements rules on how long a station should
wait to retransmit when the initial attempt to transmit a packet has
failed.  Various algorithms specify different rules for new packets and
retransmitted packets.}

procedure reschedule (var site: node);
begin site.xmtpkttime := time+maxpkttime*random(seed)*(1.0-pr)/pr;
      site.totalhits := site.totalhits+1;
end; {reschedule}

{This procedure is called when a station turns on its transmitter}

procedure transmit (var site: node; i : integer);
begin site.xmtr := on;
      xmtsignal := i;
      chnlusers := chnlusers+1;
      site.endpkttime := time+site.packetsize*8.0/bpsrate;
end; {transmit}

{This procedure is called when a station turns off its transmitter}

procedure transoff (var site: node);
begin site.xmtr := off;
      chnlusers := chnlusers-1;
end; {transoff}

{The update procedure is used for statistics gathering.}

procedure update(var site: node);
begin site.totalpkts := site.totalpkts+1;
      site.totaltraffic := site.totaltraffic+site.packetsize;
      site.totaldelay := site.totaldelay+(site.xmtpkttime-site.newpkttime);
end; {update}

{Initialization of all variables for a simulation run is done here.
The input file contains parameters for the network which may be varied
to assess the effect of changes in load, control parameters, etc.
A sample input file looks like this:

   20     10.0    127     1200.0  1.00    0.05    0.01      3
   20     10.0    255     1200.0  1.00    0.05    0.01      2
   20     10.0    511     1200.0  1.00    0.05    0.01      1

See the readln statement below for the matching variables.}

procedure initialize;
begin readln(nstations,trun,maxpkt,bpsrate,pn,pr,ptraffic,print);
      writeln('Start of Packet Network Simulation');
      writeln('N=',nstations:2,' T=',trun:5:0,
              ' maxpkt=',maxpkt:3,' bps=',bpsrate:6:0,
              ' pn=',pn:5:3,' pr=',pr:5:3,' ptraffic=',ptraffic:5:3);
      if print >= 3 then writeln('  Time  -  01 02 03 04 05 06 07 08 09 10',
                                         ' 11 12 13 14 15 16 17 18 19 20');
      seed := 12345;
      time := 0.0;
      maxpkttime := maxpkt*8.0/bpsrate;
      channel := inactive;
      rcvsignal := 0;
      xmtsignal := 0;
      chnlusers := 0;
      chnltime := 0.0;
      for k := 1 to delaycount do chnldelay[k] := 0;
      for i := 1 to nstations do
      begin station[i].state := nopkt;
            station[i].xmtr:= off;
            station[i].packetsize := 0;
            station[i].newpkttime := 0.0;
            station[i].xmtpkttime := 0.0;
            station[i].endpkttime := 0.0;
            station[i].verdelay := 0;
            station[i].totalpkts := 0;
            station[i].totalhits := 0;
            station[i].totaltraffic := 0.0;
            station[i].totaldelay := 0.0;
      end;
end; {initialize}

{At each tick of the clock the nextstate procedure updates the state of
the multi-access channel and then checks on the activity of each station.
Stations will start or stop transmitting depending on the new value of the
received signal. The internal station state variable will be updated to
reflect the situation of each node in the network.}

procedure nextstate;
begin rcvsignal := chnldelay[delaycount];
      if rcvsignal = 0 then channel := inactive;
      if rcvsignal > 0 then channel := active;
      if rcvsignal = -1 then channel := conflict;

      if channel<>inactive then chnltime := chnltime+tick;

      if print >= 3 then write(time:7:2, ' - ');

      for i := 1 to nstations do
      begin
           case station[i].state of

{No packet available state - the station is idle and has no traffic now.}

           nopkt:  nextpacket(station[i]);

{New packet state - the station has a new packet ready for transmission.}

           newpkt: case station[i].xmtr of
                   off: if channel = inactive then
                           begin transmit(station[i],i);
                                 station[i].xmtpkttime := time;
                           end;
                   on:  begin
                        if (channel = conflict) or
                           ((channel=active) and (rcvsignal<>i)) then
                           begin transoff(station[i]);
                                 reschedule(station[i]);
                                 station[i].state := oldpkt;
                           end else
                        if (channel = active) and (time>station[i].endpkttime)
                           then
                           begin transoff(station[i]);
                                 station[i].verdelay := delaycount;
                                 station[i].state := verpkt;
                           end;
                        end;
                   end;
{Old packet state - the station is engaged in retransmitting a packet.}

           oldpkt: case station[i].xmtr of
                   off: if (channel=inactive) and (time>station[i].xmtpkttime)
                           then transmit(station[i],i);

                   on:  begin
                        if (channel = conflict) or
                           ((channel=active) and (rcvsignal<>i)) then
                           begin transoff(station[i]);
                                 reschedule(station[i]);
                                 station[i].state := oldpkt;
                           end else
                        if (channel = active) and (time>station[i].endpkttime)
                           then
                           begin transoff(station[i]);
                                 station[i].verdelay := delaycount;
                                 station[i].state := verpkt;
                           end;
                        end;
                   end;

{Verification state - the station must listen to the channel to confirm that
the last portion of a transmitted has come through successfully.}

           verpkt: if channel = conflict then
                      begin reschedule(station[i]);
                            station[i].state := oldpkt;
                      end else
                      begin station[i].verdelay := station[i].verdelay-1;
                            if station[i].verdelay = 0 then
                               begin update(station[i]);
                                     station[i].state := nopkt;
                               end;
                      end;
           end;

           if print>= 3 then   {Print details of current station states}
           begin
           case station[i].state of
           nopkt:  write('  ');
           newpkt: write(' N');
           oldpkt: if station[i].xmtr = on then write(' R') else write(' .');
           verpkt: write(' V');
           end; {case}
           if station[i].xmtr = on then write('*') else write(' ');
           end;

      end;
      if print >= 3 then writeln;

{The current signal is put into a delay-line and the delay-line is updated.}

      for k := delaycount-1 downto 1 do chnldelay[k+1] := chnldelay[k];
      if chnlusers = 0 then chnldelay[1] := 0;
      if chnlusers = 1 then chnldelay[1] := xmtsignal;
      if chnlusers > 1 then chnldelay[1] := -1;

end; {nextstate}
{The following procedure is called at the end of a simulation run and
prints out the desired reports.}

procedure finalize;
var traffic, efficiency: real;
begin writeln('End of Network Simulation');
      traffic := 0.0;
      for i := 1 to nstations do
      begin if print >= 2 then writeln('Station:', i:3,
                  ' Packets=',station[i].totalpkts:4,
                  ' Collisions=',station[i].totalhits:4,
                  ' Delay=',station[i].totaldelay:7:2,
                  ' Bytes sent=',station[i].totaltraffic:6:0);
            traffic := traffic+station[i].totaltraffic;
      end;
      efficiency := 100.0*(traffic*8.0)/(trun*bpsrate);
      chnltime := 100.0*chnltime/trun;
      writeln('Summary of Network Activity');
      writeln('  Channel efficiency =',efficiency:6:2,'%');
      writeln('  Channel duty cycle =',chnltime:6:2,'%');
      writeln;
end; {finalize}
{Main program starts here }     begin

                                while not eof(input) do begin

                                      initialize;
                                      time := 0.0;
                                      while time < trun do
                                       begin
                                       nextstate;
                                       time := time+tick;
                                       end;
                                      finalize;

                                end; {of main program}

                                end.
```

station's state variable and dispatches control through use of a case statement to do the appropriate processing for the station current state. The station's state variable may be updated to a new state at the end of this processing. Finally, the currently transmitted signal or signals are fed into the signal delay line where they reside for the next five clock ticks. The 'nextstate' procedure invokes several smaller procedures for rescheduling packet traffic, turning the transmitter on and off, and generating random numbers and statistics.

The 'finalize' procedure prints a report of station activity, channel efficiency and duty cycle.

Rules for Packet Generation

The rules used for packet scheduling and transmission in this particular simulation are fairly simple. When a station is idle and has no traffic to send, it generates, on each clock tick, a random number which it then checks against variable 'ptraffic', the probability of traffic. If the random number is less than 'ptraffic', the station assumes it has new traffic. The size of the new packet is also based on another generated random number, and can be of any length less than the prescribed maximum packet.

A station with a new packet transmits immediately if there is no received carrier on the channel. If there is carrier, it waits until the carrier disappears and then transmits immediately. While transmitting it listens to its own transponded output to determine if the downlink signal is being corrupted by other transmissions. Any received errors or conflicts cause the station to stop transmitting immediately.

If the new packet transmission is unsuccessful, the transmission is rescheduled using a random delay. When the delay has expired, the station re-transmits if there is no carrier on the channel. At the end of each transmission the station must listen to the channel for 250 milliseconds to verify the correct reception of the tail end of the packet.

Here is a description of some of the events which happened during the sample run shown in Fig. 1. The run time (in seconds) is given in the left hand column.

0.15 - Stations 06 and 16 simultaneously generate packets to transmit. Transmission starts at 0.20 and is marked with a '*'. A new packet is marked by 'N' and a rescheduled packet by 'R'. After 250 milliseconds both stations discover the collision and reschedule their packets.

0.55 - Station 19 generates traffic, but there is still carrier on the channel. The carrier goes off at 0.70 and 19 commences transmitting.

0.90 - Stations 04 and 08 receive the previously started transmission from 19. There is a three-way collision and all three stations reschedule.

1.90 - Station 12 starts transmitting the first successfully completed packet. The initial delay is a wait for the carrier to clear the channel. The transmission occurs from 2.30 to 2.95. The V's indicate the verification time required for the station to listen to the tail end of its own packet coming from the transponder.

2.85 - The start of the second successful packet, by station 18 this time.

4.30 - A three-way collision involving two new packets and one rescheduled packet.

5.05 - Eleven of the twenty stations are holding for retransmit. The channel is saturating.

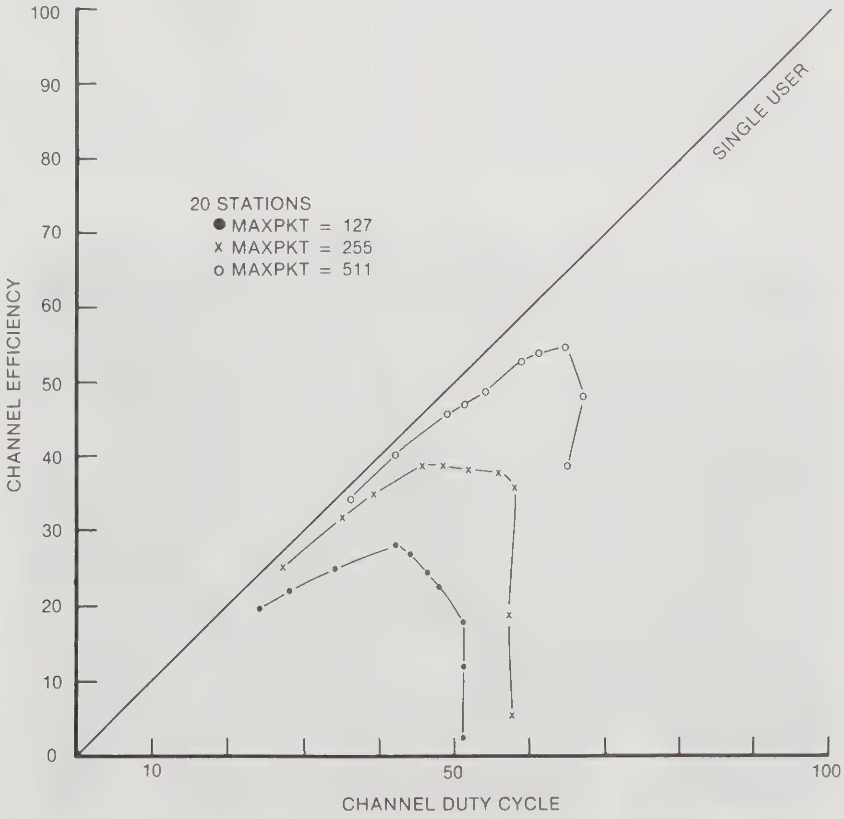


Fig. 2 - Channel efficiency as a function of load and max packet length. See the text for more details.

Summary

The statistics at the end of the run list for each station the number of successfully transmitted packets, the number of packet collisions, the total amount of time a successfully transmitted packet waited for transmission, and the total number of bytes transmitted by each station.

The channel efficiency, which is the channel time spent usefully transmitting packets divided by the total run time, is calculated. Also, a figure for the channel duty cycle is computed. The duty cycle is the total time that at least one signal was on the air divided by the total run time.

This program has now been run for over 100,000 seconds of simulated network time, and many changes to the controlling parameters have been explored. One set of runs is plotted in Fig. 2 and shows the effect of lengthening the maximum packet size. The channel efficiency increases substantially over the 18 percent predicted by analysis of the pure ALOHA* protocol because once a station has successfully captured the channel, a long packet may be sent. Also, carrier sensing helps to reduce the number of potential collisions because the packet transmission time is long compared to the round-trip signal time. It seems clear that the AMICON design should allow for channel capture and the transmission of long packets as this will significantly improve the performance in our satellite based network.

The simulation runs also pointed out the need to check some of the known methods for reducing the collisions caused when multiple stations are waiting for the carrier to drop. Quite frequently many stations are waiting for a free channel, and if all of them jump in at once, nobody wins. The standard correction for this problem is to introduce some form of randomized short delay at each waiting transmitter.

Acknowledgements

The author would like to thank the many amateurs who have contributed comments concerning the AMICON specification, and particularly Vern Riportella, WA2LQQ, who motivated me to become actively involved in designing this network.

References

1. Kasser, Joe, G3ZCZ, 'The Sky's the Limit in Amateur Satellite Communications,' *Byte Magazine*, November 1978.

*The forerunner of most Carrier Sense-Time Division Multiple Access (CS-TDMA) protocols. Developed at the University of Hawaii.

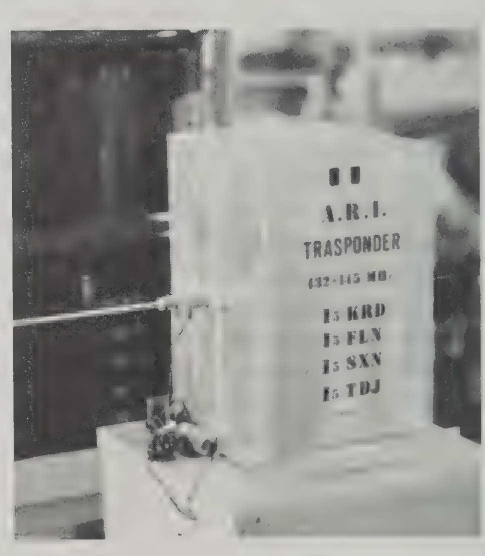
Comets

AMSAT-ITALIA Balloon Transponder

(As described by I8CVS)

I5KRD checking the 10 meter dipole on Mode A transponder. The aluminum frame is the shuttle carried up by the stratospheric balloon "NAUSICAA 2" of the National Center of Research. The balloon was successfully launched from Milo, Sicily on July 25, 1980 in the direction of South Spain. The AMSAT-ITALIA transponder makes use of three separate i-f filters with independent agc for a total passband of 30 kHz.

▼



▲The Mode B AMSAT-ITALIA transponder on top of a totally sealed Ni-Cad battery. On the back is the frame of a tank used as ballast for an experimental stratospheric balloon. Unfortunately the balloon "ERCOLE-1" of the National Center of Research failed to achieve altitude because of hydrogen leakage and was lost July 31, 1980. The transponder and balloon shuttle did not recieve damage. We plan to repeat the experiment next year.

The Project Oscar Orbital Calendar

A detailed look at procedures used to develop the monthly predictions.

By John Pronko, W6XN*

Almost a year has transpired since the first Project OSCAR orbital predictions for AMSAT-OSCAR's 7 and 8 were produced. This quarterly set of predictions was initiated when it was discovered that the longer term calendar (one year) originally provided by AMSAT was no longer accurate beyond a period of a few months from its date of publication. The difficulty centers on the fact that since we are in a period of high solar activity, the satellites are experiencing a small drag force due to the expansion of the upper atmosphere by the heat produced due to the increased radiation flux. This condition will persist until the period of maximum activity has subsided. In producing a set of accurate orbital predictions this drag force must be taken into account and unfortunately, it is difficult to predict with any degree of accuracy.

AMSAT members within the California based Project OSCAR organization volunteered, as a service to the Amateur Satellite Program, to produce a short term calendar which would include a correction for the effects due to the drag force. Since this effect was difficult to predict, it is necessary to periodically update the data. With this in mind a quarterly calendar format was chosen which would be disseminated to the user community by the fastest route possible.

The following procedure is used in establishing a data base. Periodically experimental data is examined to establish an orbital period and angular increment. Figs. 1 and 2 illustrate the trend lines observed for both of the above parameters as a function of time during the years 1979 and 1980. Not having available a convenient drag model to work with, it is assumed that the linear slope of the curves at a point in time just prior to publication of the calendar is the trend that will exist during the following quarter. Experience has now shown that under these assumptions a useful (less than or equal to 40 sec. error) set of orbital predictions can be produced for at least a three month period before an update is necessary.

*Author's address given on page 32.

Fig. 1 - Orbital period.

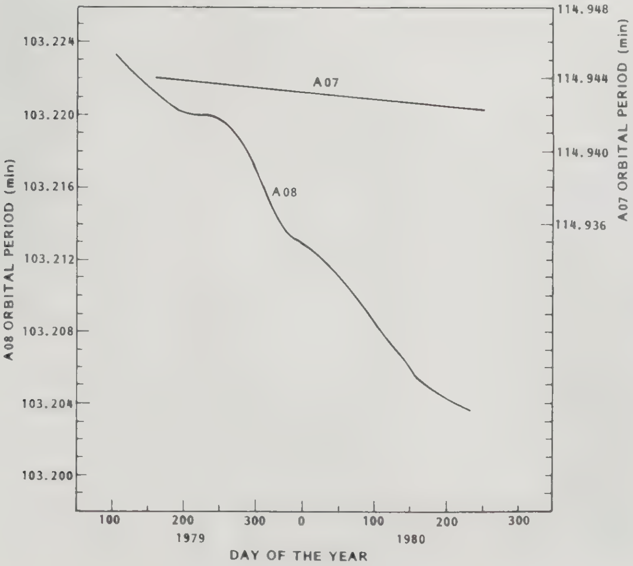
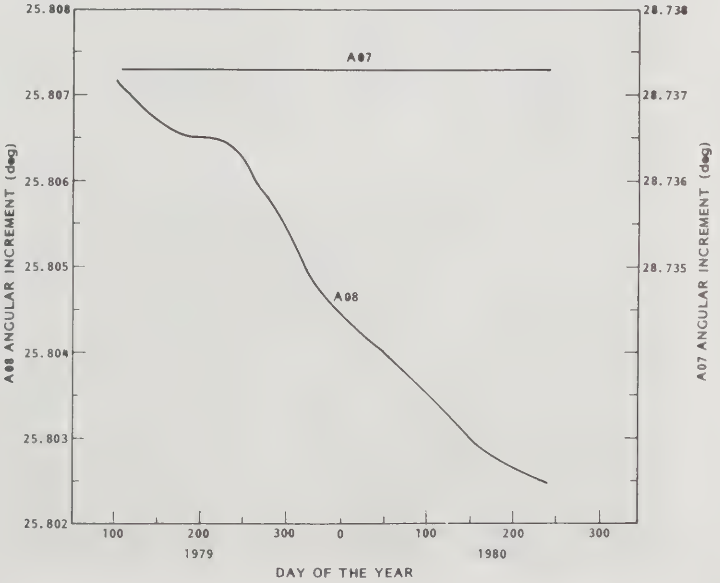


Fig. 2 - Angular increment.



Since the first quarterly calendar was produced, a general procedure has evolved. Once the equations describing the rate of change of the two parameters have been chosen and a reference point established (John Pronko, W6XN), the data is computer formatted (Randy Cole, KN6W) and pasted into calendar form (John Browning, W6SP). The formatted sheets are then photographically reduced to proper size and printed at the Henry Radio facility (Jack Somers, WA6VGS). Other Project OSCAR members who have contributed their time to the production and distribution of the orbital material are Bud Schultz, W6CG, John Fail, KL7GRF/6, and Emil Brakensiek, WA6OCT.

Reference orbits are printed in *ORBIT* Magazine and *QST*. However, satellite users can receive (every three months) a free copy of the *full* calendar by sending a No. 10 business size envelope with enough postage for 1 oz. of material to *Project OSCAR, Inc., P.O. Box 1136, Los Altos, CA, U.S.A. 94022.* The postage for requests from overseas locations can be covered by including either 62¢ postage, 3 IRC's or if more convenient $1 U.S. The orbital calendars are also available over the counter at the *Henry Radio* Store in Los Angeles.

ORBITAL PREDICTIONS

By Project OSCAR, Inc.

AO-7 Period (min/orbit) =
114.94732 ' 1.806 X 10^{-7} X (orbit no.)
Ang. Inc. (deg./orbit) = 28.7373

AO-8 Period (min/orbit) =
103.22483 − 1.711 X 10^{-6} X (orbit no.)
Ang. Inc (deg./orbit) =
25.809827 − 5.8 X 10^{-7} X (orbit no.)

Editor's Note: For complete details concerning the development of these monthly predictions, be sure to read the article by John Pronko, W6XN, beginning on page 25 of this issue.

	-- AMSAT-OSCAR 7 --			-- AMSAT-OSCAR 8 --			
U.T.C. DATE	TIME (HMM:SS)	DEG.	ORBIT NUMBER	TIME (HMM:SS)	DEG.	ORBIT NUMBER	SCHED. MODE
SAT. 1 NOV. (306)	1:39	74.4	27277	120:13	75.3	13551	J
SUN. 2 NOV. (307)	55:55	88.0	27290	125:03	76.5	13565	J
MON. 3 NOV. (308)	150:10	101.6	27303	129:52	77.8	13579	A
TUE. 4 NOV. (309)	49:28	86.5	27315	134:41	79.0	13593	A+J
WED. 5 NOV. (310)	143:43	100.0	27328	139:31	80.2	13607	X
THU. 6 NOV. (311)	43:02	84.9	27340	1:08	55.6	13620	A
FRI. 7 NOV. (312)	137:17	98.5	27353	5:57	56.9	13634	A+J
SAT. 8 NOV. (313)	36:35	83.3	27365	10:46	58.1	13648	J
SUN. 9 NOV. (314)	130:50	96.9	27378	15:36	59.3	13662	J
MON. 10 NOV. (315)	30:09	81.8	27390	20:25	60.6	13676	A
TUE. 11 NOV. (316)	124:24	95.3	27403	25:14	61.8	13690	A+J
WED. 12 NOV. (317)	23:42	80.2	27415	30:03	63.0	13704	X
THU. 13 NOV. (318)	117:58	93.8	27428	34:52	64.2	13718	A
FRI. 14 NOV. (319)	17:16	78.6	27440	39:42	65.5	13732	A+J
SAT. 15 NOV. (320)	111:31	92.2	27453	44:31	66.7	13746	J
SUN. 16 NOV. (321)	10:50	77.0	27465	49:20	67.9	13760	J
MON. 17 NOV. (322)	105:05	90.6	27478	54:09	69.1	13774	A
TUE. 18 NOV. (323)	4:23	75.5	27490	58:58	70.4	13788	A+J
WED. 19 NOV. (324)	58:38	89.1	27503	103:47	71.6	13802	X
THU. 20 NOV. (325)	152:53	102.6	27516	108:36	72.8	13816	A
FRI. 21 NOV. (326)	52:12	87.5	27528	113:25	74.0	13830	A+J
SAT. 22 NOV. (327)	146:27	101.1	27541	118:14	75.3	13844	J
SUN. 23 NOV. (328)	45:45	85.9	27553	123:03	76.5	13858	J
MON. 24 NOV. (329)	140:00	99.5	27566	127:52	77.7	13872	A
TUE. 25 NOV. (330)	39:19	84.4	27578	132:41	78.9	13886	A+J
WED. 26 NOV. (331)	133:34	97.9	27591	137:30	80.2	13900	X
THU. 27 NOV. (332)	32:52	82.8	27603	142:18	81.4	13914	A
FRI. 28 NOV. (333)	127:07	96.4	27616	3:55	56.8	13927	A+J
SAT. 29 NOV. (334)	26:26	81.2	27628	8:44	58.0	13941	J
SUN. 30 NOV. (335)	120:41	94.8	27641	13:33	59.3	13955	J

	-- AMSAT-OSCAR 7 --			-- AMSAT-OSCAR 8 --			
U.T.C. DATE	TIME (HMM:SS)	DEG.	ORBIT NUMBER	TIME (HMM:SS)	DEG.	ORBIT NUMBER	SCHED. MODE
MON. 1 DEC. (336)	19:59	79.7	27653	18:22	60.5	13969	A
TUE. 2 DEC. (337)	114:14	93.2	27666	23:10	61.7	13983	A+J
WED. 3 DEC. (338)	13:33	78.1	27678	27:59	62.9	13997	X
THU. 4 DEC. (339)	107:48	91.7	27691	32:48	64.2	14011	A
FRI. 5 DEC. (340)	7:06	76.5	27703	37:37	65.4	14025	A+J
SAT. 6 DEC. (341)	101:21	90.1	27716	42:25	66.6	14039	J
SUN. 7 DEC. (342)	0:40	75.0	27728	47:14	67.8	14053	J
MON. 8 DEC. (343)	54:55	88.5	27741	52:03	69.0	14067	A
TUE. 9 DEC. (344)	149:10	102.1	27754	56:51	70.3	14081	A+J
WED. 10 DEC. (345)	48:28	87.0	27766	101:40	71.5	14095	X
THU. 11 DEC. (346)	142:43	100.6	27779	106:28	72.7	14109	A
FRI. 12 DEC. (347)	42:02	85.4	27791	111:17	73.9	14123	A+J
SAT. 13 DEC. (348)	136:17	99.0	27804	116:06	75.2	14137	J
SUN. 14 DEC. (349)	35:35	83.8	27816	120:54	76.4	14151	J
MON. 15 DEC. (350)	129:50	97.4	27829	125:43	77.6	14165	A
TUE. 16 DEC. (351)	29:09	82.3	27841	130:31	78.8	14179	A+J
WED. 17 DEC. (352)	123:24	95.9	27854	135:20	80.1	14193	X
THU. 18 DEC. (353)	22:42	80.7	27866	140:08	81.3	14207	A
FRI. 19 DEC. (354)	116:57	94.3	27879	1:44	56.7	14220	A+J
SAT. 20 DEC. (355)	16:16	79.1	27891	6:33	57.9	14234	J
SUN. 21 DEC. (356)	110:30	92.7	27904	11:21	59.1	14248	J
MON. 22 DEC. (357)	9:49	77.6	27916	16:10	60.4	14262	A
TUE. 23 DEC. (358)	104:04	91.2	27929	20:58	61.6	14276	A+J
WED. 24 DEC. (359)	3:22	76.0	27941	25:46	62.8	14290	X
THU. 25 DEC. (360)	57:37	89.6	27954	30:35	64.0	14304	A
FRI. 26 DEC. (361)	151:52	103.2	27967	35:23	65.2	14318	A+J
SAT. 27 DEC. (362)	51:11	88.0	27979	40:11	66.5	14332	J
SUN. 28 DEC. (363)	145:26	101.6	27992	44:59	67.7	14346	J
MON. 29 DEC. (364)	44:44	86.5	28004	49:48	68.9	14360	A
TUE. 30 DEC. (365)	138:59	100.0	28017	54:36	70.1	14374	A+J
WED. 31 DEC. (366)	38:18	84.9	28029	59:24	71.4	14388	X

EME NEWS

By Al Katz, K2UYH*

In the early years, the summer was considered a time of poor EME conditions. Looking back, it appears that this feeling was caused more by the alignment of new moon with perigee in the summers than any other factor. Now ten years later, summer still has its problems. With vacations and weekend trips, activity levels seem to be down. This was definitely the case during the June weekend. Stations were on, but moon hours and contacts were few. Conditions during the August EME weekend seemed excellent and the activity level was reasonable considering how busy summer weekends can be. North American activity was helped by the ARRL's UHF contest. The early morning moon hours were ideal for catching an extra section via EME while activity was slow on the horizon.

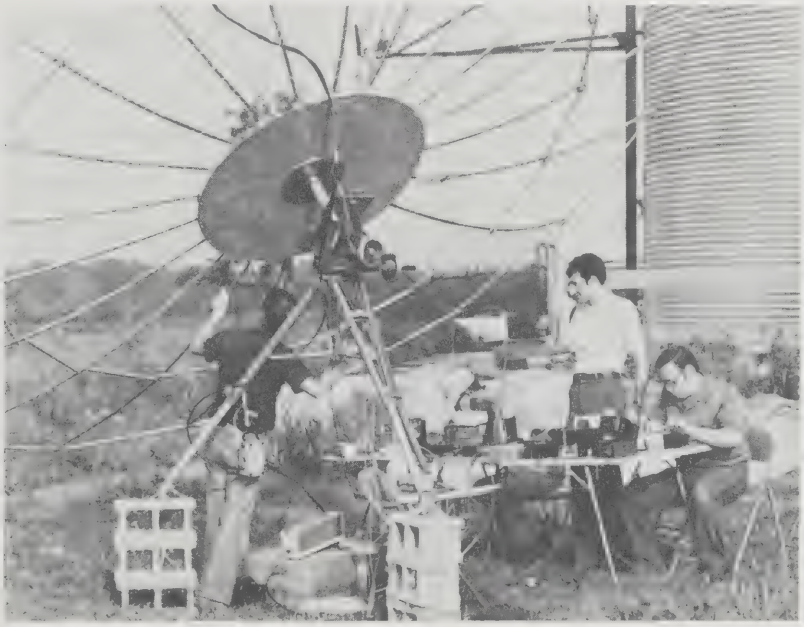
Linear polarization on 1296: Our remarks on the possibility of using loop Yagis on 1296 EME drew a number of comments—all negative. If you plan to get on 1296 EME please plan to go circular! G3WDG questions the efficiency of stacking many Yagis on 1296. He points out that the tolerances are a lot more critical on 1296 then on 432 and that for the effort involved it is much easier to get gain with a dish then with many Yagis. We are in total agreement, but can't help remembering the 60's when it was common knowledge that you could not gain many extra dB by stacking more than four Yagis on 432. Charlie (as well as others) goes on to point out that even if Faraday rotation was insignificant on 1296, that Geometric rotation would cause serious cross polarization problems. Everyone would have to use polar mounts or be able to rotate polarization. Enough said.

1296: EME activity on 1296 is growing by leaps and bounds. During the August EME weekend K4QIF worked LX1DB (0/0) initial, VE7BBG (0/0) and heard PA0SSB (0) and possibly W6YFK. Rusty definitely has gotten rid of the bugs in his 1296 MHz system. Cor, VE7BBG, also reports high activity on 1296 on August 3rd. He worked DJ4AU (first time on 1296 - 0/0), K4QIF and had a partial with LX1DB (0/0, Willy kept replying to W6YFK). G3WDG has a working 1296 system and now has an OZ9CR amp in operation. Another Charlie, W7GBI, has completed his 25 foot dish and expects to be operational on both 432 and 1296 shortly. WB5LUA has an OZ9CR amp and is hard at work on a dish for 1296 EME.

1296 Super EME Station: The Radio Club of the Geophysics Research Center at Kiruna, Sweden has obtained the temporary use of a 32-meter parabolic dish which they are equipping to conduct EME test on 23 cm. They estimate that they will be able to work stations which are using only a *1.5 meter dish, single 2C39 amp and 3 dB NF receiver!* Right now they are planning to operate two consecutive days sometime in the early fall—possibly in September but more likely in October. The call will be SK2GJ. Besides working as many stations as possible, they plan to gather polarization data (they will have both circular and linear polarizations) and observe other EME propagation effects. Preparation is well under way, so you had better get your own 1296 station going if you don't want to miss the 'WA6LET' like opportunity. Write to Gudmund Wannberg, SM2BYA, Gruvvagen 22 7TR., S-981 35 Kiruna, Sweden for first hand information.

EME Contest Results: DL9KR maintained his first weekend lead to come up with a spectacular top score on 432 of 51 contacts in 27 sections! Other top 432 MHz scorers include K2UYH with 43 x 30, F9FT with 40 x 26, I5MSH with 40 x 25 and JA6CZD with 40 x 23.

The transmitter shack and 128-element antenna at W7GBI. The operating position is 235 feet away!



K2UYH shown here pointing a 20-foot diameter portable dish at a West Virginia site. WB2DIN/8 is at the keyboard, N8II is standing and W8AEC is at the receiver.

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*Author's address given on page 32.

AMSAT NEWS

Minutes of the AMSAT Board of Directors Meeting

A meeting of the AMSAT Board of Directors was held on September 14, 1980 at the NASA Goddard Space Flight Center, Greenbelt, Md. The following people were in attendance (for part or all of the time): John Browning, W6SP*, Jan King, W3GEY*, Joe Kasser, G3ZCZ, John Henry, VE2VQ*, Pat Gowen, G3IOR*, John Pronko, W6XN, Will Webster, WB2TNC*, Rich Zwirko, K1HTV*, Bill Brown, K9LF, Tom Clark, W3IWI*, Vern Riportella, WA2LQQ, Bob Nickels, WA0OHO, Bill Tynan, W3XO, Roy Rosner, K4YV, Bob Myers, W1XT, Bernie Glassmeyer, W9KDR, and Martha Saragovitz. (*Board Member)

After a 45 minute discussion, it was resolved that the cutoff date for the mail ballots be the 28th of September 1980 as required by the bylaws. The vote on this action was unanimous.

A summary of the Financial Committee report was read by Vern Riportella. Following brief comments, Will Webster, WB2TNC, moved that the report be accepted. Tom Clark, W3IWI, seconded the motion and the vote was unanimous. It was noted that no Board action was required at that time.

Bill Brown, K9LF, gave a review on the status of fund raising for AMSAT. At this time discussions are being held between AMSAT, ARRL and the ARRL Foundation on how to proceed with a joint fund raising venture. John Browning, W6SP, thanked Bill for his efforts on behalf of the Board. In addition, the Board voted to set up a new office, Vice President - Special Projects.

After a lengthy discussion, the Board agreed to endorse the concept proposed by the AMSAT group at the University of Marburg (Federal Republic of Germany) concerning the construction program for the Phase IIIB satellite and suggested that a memorandum of understanding be written between AMSAT and the AMSAT group at the University of Marburg clarifying additional details. The vote was five in favor, one against (WB2TNC) and one abstained (W3GEY).

An update on the state of the ARRL Foundation was given by Bernie Glassmeyer, W9KDR. Following this, the Board complimented the ARRL on their new publication *Amateur Radio*. Tom Clark, W3IWI, then commended the ARRL for their help in the process of obtaining an STA for the HF-PSK tests.

A discussion on the nets was initiated by Will Webster, WB2TNC. Due to world-wide interference the Board decided to move the frequency of the 20 meter net to 14.282 MHz. In addition, it was noted that other sources are needed to conduct additional HF nets at other times to improve communications capablility.

After discussing membership and membership status, it was moved by Will Webster, WB2TNC, and approved unanimously by the Board that a study of all aspects of membership planning be undertaken. Vern Riportella, WA2LQQ, will manage the study which is to be completed by the next Board meeting.

Following a review of *ORBIT* Magazine and the release of information, the Board agreed that AMSAT as a general policy desires the availability of *ORBIT* Magazine for OSCAR users around the world and that the *ORBIT* staff be directed to provide suitable distribution channels. A short term study was commissioned to propose methods by which a weekly newsletter be circulated to key individuals and organizations. The vote was five in favor and one (WB2TNC) abstained. Bob Nickels, WA0OHO, will make the report within 60 days. In addition, the *ORBIT* staff was directed to prepare a budget for calendar year 1981. Joe Kasser, G3ZCZ, tendered his resignation as Editor of *ORBIT* effective as of the Spring Meeting of the Board of Directors.

The election of officers was then held, with the following results: Chairman of the Board: John Browning, W6SP (W6SP abstained), President: Tom Clark, W3IWI (W3IWI abstained), Executive V.P.: Vern Riportella, WA2LQQ (unanimous), V.P. Engineering: Jan King, W3GEY (W3GEY abstained), V.P. Operations: Rich Zwirko, K1HTV (K1HTV abstained), V.P. Special Projects: Bill Brown, K9LF (unanimous), Corporate Secretary: Martha Saragovitz, Secretary to the Board: Joe Kasser, G3ZCZ (unanimous), Treasurer: Roy Rosner, K4YV (unanimous).

The Board then reaffirmed the motion of the previous Board meeting concerning their desire for an international meeting to be held and commended the positions recommended by Jan King, W3GEY, and Karl Meinzer, DJ4ZC, for further study. The vote was unanimous. A brief report on AMSAT activity in New Zealand and Holland was then given by Tom Clark, W3IWI.

The Board moved that OSCAR awards be presented for meritorious services to the following radio amateurs: K9CIS and KH6OS for consistent excellent telemetry reporting, and WA4SNL for aid and assistance in the W3ZM repeater. All Board members unanimously approved.

Tom Clark, W3IWI, then moved that whereas Roy Stevens, G3BVN, having given faithful service to the amateur satellite program and whereas Roy Stevens having been awarded the MBE, AMSAT would also like to put its commendation on record. The Board voted and all were in favor. The awarding of Life Memberships in AMSAT for Jan King (W3GEY) and Karl Meinzer (DJ4ZC) for services rendered in the Phase IIIA construction program was approved by the Board. Pat Gowen, G3IOR, further moved that a suitable recognition be awarded to Perry Klein, W3PK, for his services to AMSAT and the amateur satellite program. The vote in favor was unanimous.

Observations on the AMSAT Meeting September 13, 1980

Mind boggling details of past, present and future amateur satellites presented by a number of responsible AMSAT people with nary a reference to a written note.

High level of interest shown by the attendees hour after hour after hour.

Rip, WA2LQQ, and his pride-and-joy computer plotting orbital data for visiting hams covering various longitudes and latitudes.

The attention that was focused on the WIG making the rounds of the good natured notables.

The efficiency with which the election clerks functioned.

The reserved and quiet dignity of the ARRL representatives.

The announcement that another barrier in the annals of satellite communications had been broken—WAC via Satellite.

The rapid and unruffled dispatch of huge quantities of strip steaks coming from a one-man kitchen.

The failure to formulate a firm financial plan for the future launchings despite the amount of time spent explaining the need.

The absence of any mention of the scholarship program.

The non-stop ability of the master of ceremonies to tie together any loose ends.—*W0CA*

Area Co-ordinator Update

France: Change of Address—Gerard Francon, F6BEG, 69 Rue Bataille, 69008 Lyon, France.

Mode 'M' Transponders under Development

AMSAT groups in all three IARU regions are at work developing transponder technologies for possible use in future spacecraft in the OSCAR series. These transponders, have an uplink at about 1260 MHz and a downlink at about 436 MHz.

Since three different groups have independently decided to investigate 1260/436 MHz transponder technology, it looks like Mode M is the way of the future.

Note that AMSAT's policy is to minimize user equipment obsolescence. Should a Mode M transponder be flown on a Phase III spacecraft in the near future, it will be in *addition* to a Mode B transponder rather than instead of it.

Son Born to G3ZCZ

Fay and Joe Kasser (G3ZCZ) announced the arrival of their son Michael, born on 28 August 1980. Michael was born a few months after the abortive launch of the Phase IIIA spacecraft. Their first child Susan, was born a few days after the launch of the AMSAT-OSCAR 7 spacecraft. Lisa, their second was born a month or so after the launch of AMSAT-OSCAR 8. Since their first boy was born following an unsuccessful launch, what do we wish them for the next time? We wish Fay and Joe and their three redheads all the best for the future.

WA3NAN Net Controller gets Married

Will Webster, WB2TNC, well known as the voice of WA3NAN, Net Control of many AMSAT nets, suprised most of his friends and aquaintances by marrying Toni Cor on 28 July 1980 at Laramie, Wyoming. WA3NAN missed several nets while Will and Toni were honeymooning in West Virginia. We wish Will and Toni all the best for the future.

W3GEY Recieves the John C. Chambers Memorial Award

Jan King, W3GEY, was awarded the John C. Chambers Memorial Award at the Central States VHF Society's 14th Annual Conference, held at Colorado Springs.

The Award was presented to Jan for outstanding contribution to the OSCAR Satellite Program. Jan accepted the award on behalf of *all* those who worked with him on the OSCAR program.

Ballots

Of the more than 1200 ballots cast for this election, only 756 came from the USA. Of the remainder 220 came from Japan, 41 from Canada, 26 from France, 23 from Australia, 21 from the United Kingdom, 18 from Germany, 17 from New Zealand, 14 from Belgium and 11 each from Holland and South Africa.

The remaining ballots came from all around the world including such exotic DX locations as Nepal, Surinam, Cook Islands, French Polynesia, New Caledonia, Singapore, Thailand, Gabon, Botswana and Zambia.

The massive turnout reflected the enormous interest in this election—*G3ZCZ*

AMSAT Nets

Late breaking news and technical information are often carried on the hf and vhf/uhf AMSAT Nets. Why not listen in or better yet, join in with your local network.

S.E. Asia

14.275 MHz, NCS: JA1ANG

USA:

Sundays: 0800 Eastern, 7.280 MHz, NCS: W4MID
Sundays: 1800 UTC, 14.282 MHz, NCS: WA3NAN
Sundays: 1200 UTC, 7.280 MHz, NCS: W4MID
Wednesdays: 0100 UTC, 3.850 MHz, NCS: WA3NAN
Wednesdays: 0200 UTC, 3.850 MHz, NCS: W0CY
Wednesdays: 0300 UTC, 3.850 MHz, NCS: W6CG

InterContinental:

Sundays: 1900 UTC, 21.280 MHz, NCS: WA3NAN

Net Control stations, worldwide are invited to publicize their networks in these pages. Mail in your date, time and frequencies for listing herein.

Additional Net Control Stations are required. Volunteers write to AMSAT Operations, P.O. Box 27, Washington, DC 20044.

AMSAT Software Exchange

A.S.E., a non-profit organization to distribute public domain programs for computer and calculator users, AMSAT members and non-members alike, is being organized by Jim Wiman, WD9ICG, and Bob Diersing, N5AHD.

A.S.E. needs satellite related programs that are in the public domain. A.S.E. also needs computerists who are willing to support software exchange of programs for their systems. For systems that are not handled in the media needed, Disc, cassette, paper tape, they will have to be paper listings (Please send good legible copies). Calculator users should use their respective programming forms. If support is available for the major systems in their respective media, there will be a fast effective exchange.

The programs can be of any satellite related subject. They need no documentation, but as you write new ones don't hesitate to 'REMark' them well. An alternative would be to write a concise, fast program and then write a second 'REMark' file to allow a chance to learn your programming techniques. Send your programs and feel confident that others will make good use of them. It provides us with the means to bring Amateur Radio, satellite communications and computers together providing an effective and powerful system. Send all inquiries to: A.S.E. (AMSAT Software Exchange), P.O. Box 338, Ashmore, IL 61912—*WD9ICG*

W0CA and his WAC certificate. This is the first ever satellite WAC.

AMSAT Election Results

The official ballot count of all votes cast at the 1980 Annual Meeting and those that arrived by mail on or before Sept. 28, 1980 is as follows:

W3IWI	1041
G3IOR	871
JA1ANG	825
K1HTV	527
VE2VQ	444
W3XO	379
W0CY	255
ZS1BI	250
W0RUE	197
W4DWN	172

Thus W3IWI, G3IOR and JA1ANG are elected for two year terms. K1HTV was elected for the remaining one-year term held by W3PK prior to his resignation earlier this year. The plurality of the vote for W3IWI is seen as a resounding vote of confidence in his leadership.

Will Webster, WB2TNC (the voice of WA3NAN) shown perusing a copy of *ORBIT* at the AMSAT Board Meeting.

Life Members

AMSAT gratefully acknowledges donations of $200 or more from the following new Life Members.

Bruce Roggenkamp, WD9FMI
W.L. Robb, VK3YR
Bill Klemacki, VE3XJ
Reino Talarmo, OH3MA
Edward Hartwick, WB0FAQ
Seiji Agarie, JR6CE
Gary Poague, WB0SCV
John Syner, WA3UVU
Isamu Sakiyama, JR6DM
Si Ge Ru Chinen, JR6SXW
Dave Crowhurst, VE3XCF
W.E. Butler, W2WD
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JA3JM shown at the AMSAT Annual Meeting. The chalkboard shows a sample of the callsigns of some of those present at the meeting.

Comets

A Review of Sat Track International's Software Products

A back burner project of mine for quite some time has been the development of computer programs for tracking earth satellites. My program, originally written in Fortran and later translated into APL and C, worked fairly well for low-orbit satellites in circular orbits, such as the OSCAR's and Skylab. It took equator crossing time information from the *AMSAT Newsletter* or W1AW and calculated the azimuth, elevation and range figures for my station location. A number of simplifying assumptions were made; for example, the earth was assumed to be a perfect sphere, the orbit a perfect circle, etc.

When the use of elliptical orbits for Phase III satellites was announced, however, I found out just how much more complicated the math would have to be! When I was about to give up, I came across a small item in *Computerworld* magazine advertising inexpensive tracking software from Sat Trak International (STI).

STI is a small company based in Colorado Springs, Colorado, run by Dave Cooke and Bill Barker. They have written a number of very powerful programs to track earth satellites, available in Basic for various popular personal computers, and in Fortran. I have so far obtained the TRS-80 Basic and Fortran versions, and I must admit that they are far better than anything I could write myself. Their package uses as input the six classical orbital elements of a satellite, available from NASA on a regular basis free of charge. Their model allows any type of orbit, elliptical or circular, and takes into account the various perturbations caused by the oblateness of the earth.

There are several programs available individually, or in a package. A cassette containing the whole Basic package for the Apple II, Sorcerer or TRS-80 is $39. The Fortran listing with a 1800-card deck is $65. ($40 without cards, but just how much typing are you willing to do to save $25?) Unfortunately, the programs aren't available in other forms, such as industry standard magtape. Perhaps with enough requests, STI will expand the available formats.

POSN calculates the position of a satellite as a function of time. Outputs are the latitude and longitude of the subsatellite point, along with the altitude.

LOOK built as an extension of POSN calculates the look angles (azimuth and elevation for antenna pointing, right ascension and declination for telescopes) for any specified point on the earth to a satellite, along with the slant range (distance).

As the authors designed these programs to be useful in optical sighting, they allow an option to specify that only visible passes be generated. A visible pass is one which the observer is in darkness, and the satellite is illuminated by the sun. The program even calculates the angle formed between the sun, satellite and observer. This indicates the relative brightness of the satellite, as lower angles mean that more of its illuminated side is facing the observer. With this information, it is possible to predict the point at which OSCAR enters or exits the earth's shadow, and it can be easily verified with the solar array current telemetry channel.

Although I haven't tried it, it might also be possible to predict lunar or solar eclipses by entering the moon's orbital elements. Running the program and looking for a zero or 180 degree angle would indicate a lunar or solar eclipse, respectively. Maybe an interested user could try this out.

OBS updates the classical orbital elements based on an actual observation of a satellite pass. Entering the time of culmination (maximum elevation) allows the program to update the satellite's orbital parameters. This may be used to keep the other programs accurate until a new NASA bulletin arrives.

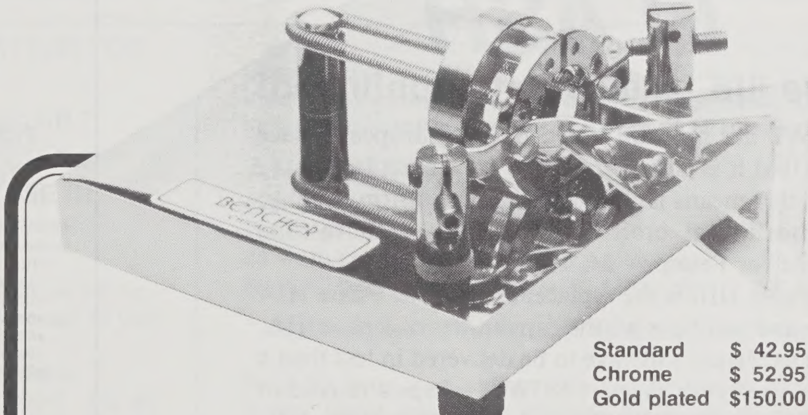
TRAK (Basic versions) Modification of POSN that uses a graphics screen to plot satellite position on a world map, 'Mission Control' style.

I was able to bring up both the Basic and Fortran versions of STI's software without too many problems. When I first ran the Fortran version on a PDP-11/70 UNIX system, I kept getting errors that complained about a function not converging. The errors stopped after I put an IMPLICIT DOUBLE PRECISION statement at the beginning of each subroutine. Other machines may or may not require the use of double precision; the STI literature claims that it is not required.

The TRS-80 Basic version came up without any problems, but if you're used to fast response, be prepared to wait a while for anything to happen. A hobby microprocessor running interpretive Basic just isn't a very powerful machine when it comes to lots of floating-point number crunching. It will usually take several minutes for LOOK to start printing passes.

The programs as supplied are very easy to use; no knowledge of orbital mechanics is needed, and only an average understanding of Basic or Fortran is needed in case you have minor compatibility problems with your machine. The manual is well written, and it gives sample output using test data to verify that your program is working properly. I have called Dave Cooke several times on the phone with questions about the program, and each time I have found him to be extremely patient and helpful.

At my own station, LOOK is, of course, the most often used program. I print out a series of passes for an entire week at a time, and refer to it when operating. As far as I can tell, the predictions are right on the money! AOS and LOS on the OSCAR 7 Mode B downlink usually occurs within seconds of the satellite's predicted rising and setting times. The next step at KA9Q is interfacing the program's output to drive the antenna rotors and tune the receiver and transmitter to compensate for Doppler. Perhaps when I'm all done, I'll be able to make contacts via OSCAR without having to have six hands—*KA9Q*



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Have an idea for an article you would like to write for ORBIT? *Drop a note to: Editor,* ORBIT *Magazine, P.O. Box 27, Washington, DC 20044.*

FLASH

Phase IIIB Launch Date Confirmed!

AMSAT has been informed by the European Space Agency that it is 'selected for the L7 launch.'

What this means is that we now have a firm 'ride' to the high-elliptical orbit for the Phase IIIB satellite scheduled for February 24, 1982.

The Phase IIIB is the replacement for the Phase IIIA satellite and will have all the capabilities of Phase IIIA.

Since hardware will have to be delivered in less than a year, we need your support NOW. Perhaps a re-read of W3IWI's article in *ORBIT* No. 3, page 22, will illustrate the urgent need for your contribution today.

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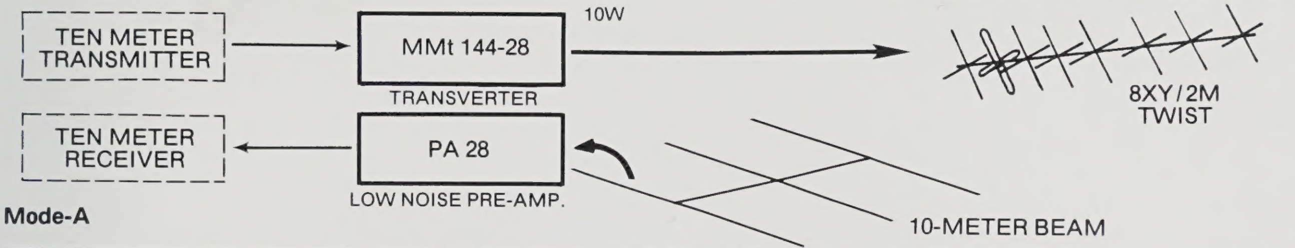

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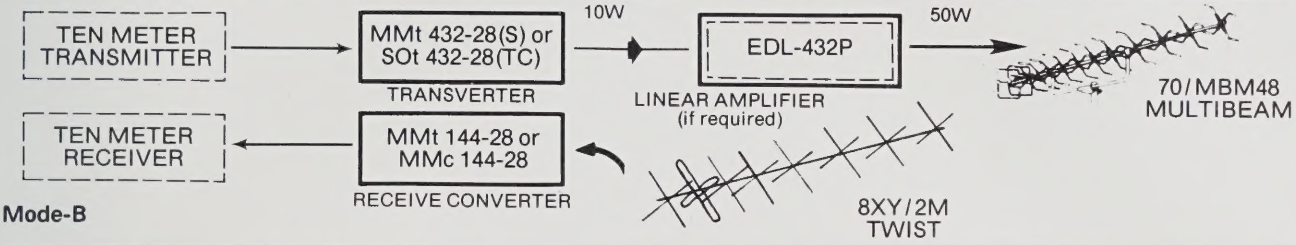

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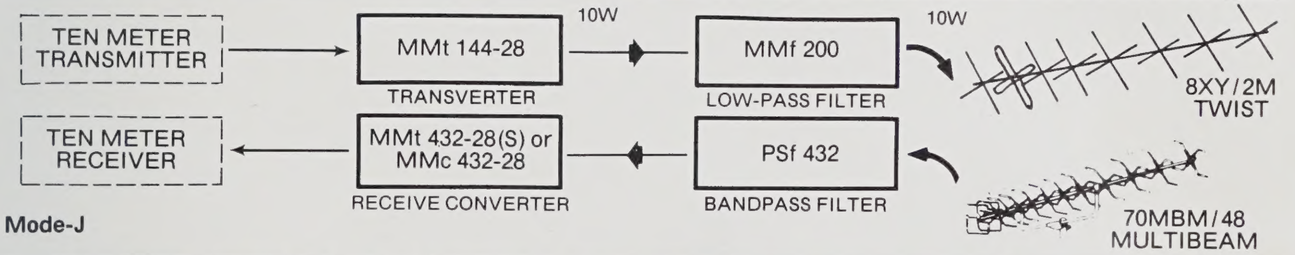

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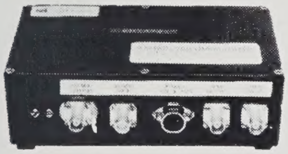
CONVERTERS AND TRANSVERTERS FOR



OSCAR 7
OSCAR 8
PHASE III

Specifications:

Output Power: 10W.
Receiver N.F.: 3 dB typ.
Receiver Gain: 30 dB typ.
Prime Power: 12 Vdc

Receive Converters:

MMc 144	$59.95
MMc 432-28(s)	$89.95
MMc 432-28(TC)	$84.95

UHF Filters:

MMf 200-5	$31.95
MMf 200-7	$42.95
PSf 432	$59.95

Receive Preamplifier:

PA-28	$35.95

Mod. kit to adapt original MMt 432-28 FOR Mode-J operation: $26.50

Transverters by Microwave Modules and other manufacturers can convert your existing low-band rig to operate on the VHF and UHF bands. Models also available for 2M to 70 Cm and for ATV operators from Ch2/Ch3 to 70 Cm. Each transverter contains both a Tx up-converter and an Rx down-converter. Write for details of the largest selection available.

Attention owners of the original MMt 432-28 models: Update your transverter to operate OSCAR 8 and Phase III by adding the 434 to 436 MHz range. Mod. kit including full instructions is $26.50 plus $1.50 shipping.

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2-Meter 8 + 8 Twist Model 8XY/2M	$57.75
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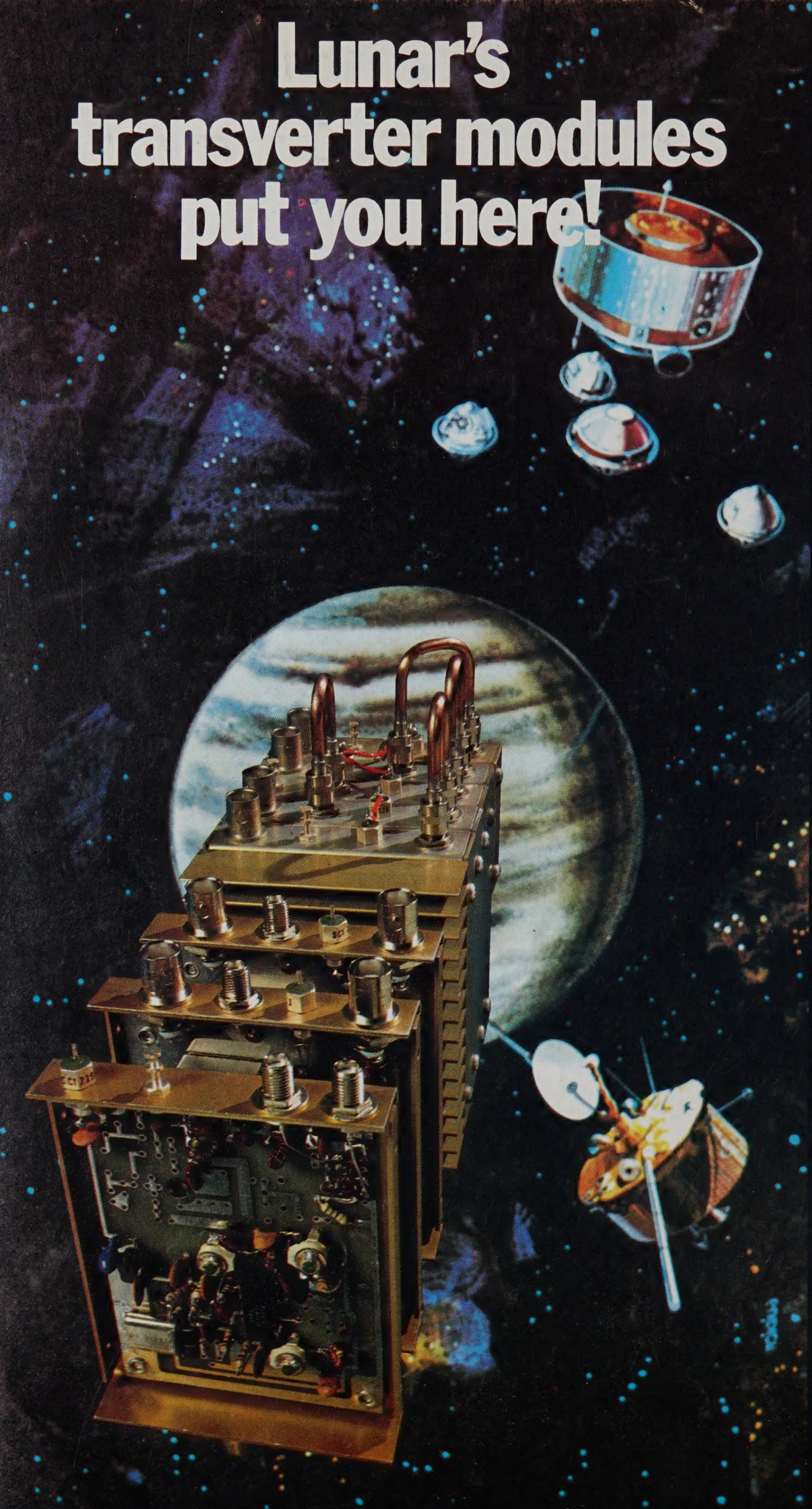

Adding various combinations of Lunar's transverter modules to your present station greatly expands your capabilities to: work an Oscar including Phase III; receive noise from the sun for solar flare investigation or for plotting galactic noise sources; receive weather satellite transmission ;or practically anything else found on HF through UHF.

Our transverter modules are distinctly different from the usual transverter or the home built transverter module. With the single band transverter you must purchase a different unit for each additional band you wish to cover.

Lunar's transverter modules, on the other hand, start with the basic down converter for receive and up converter for transmit. Selecting an appropriate local oscillator module determines the band. Additional modules are added to achieve desired receiving NF and/or output power. Changing the local oscillator module changes the band. Pre amps you already have or might build may be used as desired, similarly, for the transmit side.

It's easier than building your own modules from scratch, and costs much less than buying a complete transverter for each additional band.

Some examples of expected performance using Lunar modules.

EXAMPLE 1

Selected modules:
DC 28
LO 28/144
UC-VHF
PAD 144
PAM 144
This combination gives you:
RF: 144 to 146MHz
IF: 28MHz to 30MHz
Conversion Gain: 25dB
Overall NF: 2 dB nom. 1.6 dB typical
Image Rejection: –30 dB typical
LO Purity: –50 dB max. all spurs & harmonics
Drive 28MHz: 1 to 5 mW
Power Output: 20 watts min.
Operating Voltage: 24VDC @ 2.5 amps. nom.

EXAMPLE 2

Modules added to Ex. 1
LO 28/220/222
PAM 220
PAD 220
This gives you:
RF: 220-222, 222-224MHz
Conversion Gain: 22 dB
Overall NF: 2.5 dB typ., 2.2 nom.
Other specs. remain the same.

If you have a specific band you'd like to cover, write or call us and we'll be happy to discuss it with you. Or send for our literature on transverter modules.

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